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Flathead Basin Commission

1995-1996 Biennial Report

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The Flathead Basin Commission

A Non-Regulatory Approach to Protecting Water Quality

Created by the Montana Legislature to monitor and protect water quality in one of the state's most important watersheds, the Flathead Basin Commission is a uniquely structured non-regulatory organization that works to accomplish its important mandate in a consensus-building manner, stressing education, cooperation, broadly-based community involvement and voluntary participation.

The 22 members of the Commission represent a wide cross-section of citizens and local, state, tribal, federal and provincial agency representatives who strive to identify the basin's water quality problems and work collectively to implement the most effective solutions.

The Flathead Basin Commission has become a model of successful citizen, inter-agency cooperation in a geographically vast and ecologically diverse watershed characterized by its overall pristine character, international dimensions, and multi-jurisdictional nature.

This report summarizes the Commission's activities, initiatives and water quality monitoring data collected and analyzed during the 1995-1996 biennium. Those wishing more detailed information regarding any aspect of the Commission and its activities are encouraged to contact us.

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Letter From The Chair

Dear Members of the Legislature and Governor Racicot:

It gives me great pleasure to present the Biennial Report of the Flathead Basin Commission. As you page through it, you'll see an amazing list of projects and accomplishments for a 22-member group made up of various government representatives, six citizen volunteers who serve with no pay, and one staff person. It is our belief, as it was the Legislature's belief in 1983 when it established the Commission, that it is easier (and much more cost effective) to keep water clean than to clean up a mess.

We are continuing the critical function of maintaining oversight of water quality to nurture this vital part of Montana's economic prosperity. Unceasing rapid population growth (one of the fastest growth rates in the state) challenges the ability of the Flathead Basin to provide the environmental quality that residents, new ones and old-timers alike, have come to expect.

The relatively small budget provided by the Legislature to cover the Commission's basic operating expenses importantly leverages our ability to use other funds for key projects, always earmarked for their specific purpose. Among these are water quality monitoring (both volunteer and professional), educational forums, and other essential activities you will read about in this report. The approximately $82,000 provided by the 1995 Legislature was leveraged into more than $300,000 by other sources in cash and in-kind contributions.

Our largest and most time-consuming project since late 1994 has been fulfilling the Montana Department of Environmental Quality mandate to develop a Total Maximum Daily Load (TMDL) for Flathead Lake. This is a cooperative project, made possible by funding secured by U.S. Senator Conrad Burns, involving the Confederated Salish and Kootenai Tribes, the University of Montana, the timber industry, agricultural interests, citizen volunteers, and a broad range of local, state and federal agencies.

The report is due in spring 1997. We plan to recommend that whatever level of protection is necessary, the measures to make that happen should be identified by the people of the Flathead Basin and be implemented on a voluntary basis, not created or imposed by bureaucrats far away. We hope to be able to identify incentives that will make it easier for small enterprises, families and individuals to adopt volunteer solutions. We want a solution crafted in the Flathead watershed, not in Helena or Washington, D.C.

It has long been my belief that local people can find a solution to any problem, if given the specialized information needed to make the decisions. Nobody wants dirty water.

We know that the Legislature will likely address the issue of TMDLs in the 1997 session. We are confident that we can develop voluntary strategies that will take into account the legitimate interests of the Legislature and other entities. We plan to begin "solution" meetings in the near future, and hope to have some answers ready to put into place this year and next.

With the continued support of the Legislature and the Governor in this unique citizen/government partnership, we can maintain our watch over the Flathead Basin's vitally important water resources. We look forward to continuation of the cooperative process that has been and continues to be successful.

Sincerely,

Elna Darrow

Elna Darrow, Chair

The Flathead Basin

A World Class International Watershed

The creation of what today is known as the Flathead Basin can be traced to momentous geological activity 150 million years ago that led to the formation of the Rocky Mountains. Glacial activity, which began about three million years ago with a series of "ice ages" in the Northern Rockies, gradually shaped the physical character of the land, sculpting its river valleys and mountain ranges into what we today know as the Flathead Basin. Many of the area's most significant geological attributes, including Flathead Lake and the glaciers in Glacier National Park, are the living reminders of the end of the last ice age just 10,000 years ago.

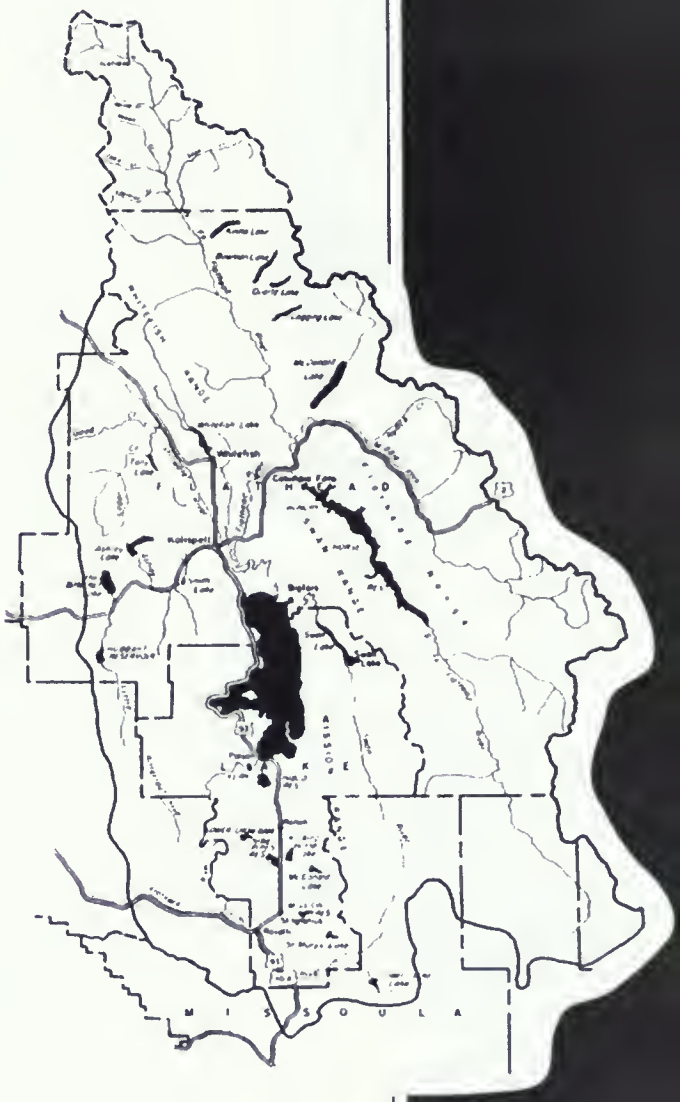
The watershed encompasses 8,587 square miles — approximately six million acres — in Southeastern British Columbia and Northwestern Montana. The long, north-south axis stretches 175 miles, while the maximum width is 88 miles.

The Flathead River drainage is the largest tributary to the Clark Fork River, which is tributary to the Columbia River. The river's three forks — North, Middle and South — together supply approximately 80 percent of the water carried within the watershed. Other rivers in the basin include the Stillwater, Whitefish and Swan. The lower Flathead River below the outlet of Flathead Lake empties into the Clark Fork River at the town of Paradise at an elevation of 2,500 feet above sea level.

Elevations elsewhere in the watershed range from Mount Stimson in Glacier National Park at 10,142 feet to 2,893 feet at Flathead Lake, the drainage system's major catchment. The lake is the largest body of fresh water in the U.S. west of the Mississippi River with a full pool surface area of 126,000 acres. The Basin contains over 500 lakes, which range in size and character from nearly inaccessible alpine lakes of only several surface acres to Flathead and other large bodies of water, including Swan, McDonald, Whitefish, Tally, Blaine, Little Bitterroot and Echo lakes.

The watershed maintains remarkably diverse communities of plants and animals, including over 300 species of aquatic insects, 22 native and introduced species of fish. Four species are listed under the federal Endangered Species Act as threatened (grizzly bear and bald eagle) and endangered (peregrine falcon and gray wolf), and the bull trout is proposed for listing. Although a variety of human influences have seriously reduced populations of many native species, the region still supports all the wildlife species that were here at the time of the Lewis and Clark Expedition.

Included in the watershed are virtually all of Flathead and Lake counties and the Flathead Indian Reservation; the portion of Glacier National Park west of the continental divide; parts of three wilderness areas; millions of acres of forest land under federal, provincial, state, tribal and corporate management; and thousands of acres of privately owned property.



For a more detailed discussion of the watershed's physical features, refer to "Flathead River Basin Environmental Impact Study Final Report," available at libraries or at the Commission office.

"...a COOPERATIVE strategy among all LAND and WATER management agencies within the Flathead Basin..."

1995-1996: The Commission On The Move

An Inclusive, Dynamic Approach to Watershed Issues

To make involvement in watershed issues possible for the greatest number of Basin residents, the Commission conducts bi-monthly, day-long meetings in communities throughout the Basin. By focusing agenda discussions on single, timely topics, the Commission is able to present a balanced program of accurate, up-to-the minute information on subjects ranging from cooperative resource management strategies with British Columbia to updates on water quality monitoring data. During the biennium, the Commission conducted meetings in Pablo, Polson, Bigfork, Kalispell, Whitefish, Columbia Falls, and Fernie, British Columbia.

Special presentations made at Commission meetings during the biennium included:

- Briefing by Andy Birnell, leader for the Inter-Government Cooperation team for the Upper Columbia River Basin Environmental Impact Statement process
- Updates on Voluntary Nutrient Reduction Strategy study by consultant Ron Cooper
- Presentation on Project Free Flow, an elementary through high school monitoring program, by coordinator Susan How and science instructor Chris Ruffatto
- Update on the Swan Valley Accord, an agreement among several agencies and Plum Creek Timber to establish a coordinated strategy for conserving grizzly bear habitat in the Swan drainage
- Briefing by Steve Pilcher, administrator of the Environmental Sciences Division of MDHES, on the characteristics of proposed water quality legislation
- Update on tribal water quality regulations by Marian Yoder, CSKT attorney, and Bill Swaney, CSKT Natural Resources
- Presentation by economist George Darrow on economic and growth trends in the Flathead Basin and the prospect for developing a "durable economy" in the basin
- Panel discussion of bull trout-related issues by Larry Peterman, head of MDFWP Fisheries Division and chair of Governor Racicot's Bull Trout Restoration Program; John Fraley, MDFWP Region One Public Information Officer on the program's education and information strategy; Jim Vashro, MDFWP Region One Fisheries Manager, on bull trout population trends in the Flathead Basin; Joe Dos Santos, CSKT fisheries biologist on the bull trout fishery on the Flathead Indian Reservation; and Glenn Marx, natural resource policy advisor to Governor Racicot, on the role of the governor in the bull trout issue
- Update of the state's 1984 phosphorus strategy, its successes and basis for the Commission's Voluntary Nutrient Reduction Strategy, by Dr. Loren Bahls, MDEQ
- Briefing by Gail Kuntz, Bonneville Power Administration, on a study designed to create a new governance structure to allow for more effective regional control over efforts to conserve and enhance anadromous and resident fish and wildlife within the federal Columbia River power system
- Presentation by Mary Ellen Wolfe, Montana Watercourse, on the community-based "Know Your Watershed" education program and plans for conducting the program in the Flathead
- Annual "State of the Watershed" briefing by Dr. Jack Stanford, University of Montana Biological Station Director
- Briefing by Dr. Paul Smiley, chair of the Flathead County Conservation District supervisors and Dennis DeVries, chair of the Lake County Conservation District supervisors, on the role of conservation districts in water quality issues in the Basin
- Report by Dr. Jack Stanford on a diagnostic study to document nutrient loading at Swan Lake
- Presentation by Kim Potter, Flathead County Disaster and Emergency Services director and Jolene Jacobson, CSKT Tribal Emergency Response Committee (TERC), on efforts being carried out in the Basin to deal effectively with threats posed to water quality and public safety by hazardous materials
- Preliminary report by Bonnie Ellis, University of Montana Biological Station, on the ongoing Voluntary Nutrient Reduction Strategy, including summaries of data collected on phosphorus

Inter-agency cooperation was demonstrated by the participation of CSKT researchers during the Commission's study to identify sources of nonpoint pollution upstream from Flathead Lake. Seth Makepeace collects data on the Stillwater River north of Kalispell.

and nitrogen levels in Basin watersheds
- Update by Rich Moy, MDNRC, and Dennis McDonald, British Columbia liaison, on status of the draft mutual cooperative agreement between Montana and B.C.
- Report by Larry Mitchell, Environmental Quality Council resource policy analyst, on the EQC's "Environmental/Natural Resource Compliance and Enforcement Study," a three year effort to analyze concerns related to state agency enforcement of environmental regulations.

A Leadership Role in the Flathead Basin

To ensure the highest level of coordination with agencies, organizations and the public and to carry out its recognized leadership role in water quality issues in the Flathead Basin, the Commission, through staff participation, maintains ongoing involvement in a number of key organizations and processes, on both the local, regional and state level. Included are:
- Montana Watershed Coordination Council, a multi-agency, Helena-based organization that addresses and coordinates watershed issues on a state-wide basis
- Montana Watercourse Board of Advisors, which provides advice and guidance to enhance the effectiveness of educational programs initiated by the Montana Watercourse and Project WET Montana
- Environmental Education Core Group, a northwest Montana-based effort that coordinates and advances the presentation of responsible environmental and natural resource presentations in schools and for the community
- Flathead Groundwater Coordinating Committee, an association of agency and private sector representatives that serves as the Commission's technical advisory committee for groundwater issues
- Kalispell Area Chamber of Commerce Natural Resources Committee, which provides policy direction to the chamber board on natural resource issues
- Community Celebration — Living in the Landscape, a broadly-based effort to recognize the unique natural and cultural characteristics of the Flathead through a series of complementary events and projects planned for 1998.

Dr. Jack Stanford, Director, UM Biological Station, delivers his annual "State of the Watershed" report to the Commission. Bio Station researchers conduct Flathead Lake monitoring and analyse upstream and other lake data collected by agency researchers and volunteers.

The Commission in Transition

Vice Chair Elna Darrow succeeded Larry Wilson as Commission Chair while Joel Holtrop, Flathead National Forest Supervisor, succeeded Darrow as Vice Chair.

During the biennium, Holtrop left the Commission to accept an appointment to the U.S. Forest Service headquarters in Washington, D.C. and was replaced by Rodd Richardson, the new Flathead National Forest Supervisor. Bill O'Brien, MDNRC Northwest Lands Area Manager, retired from state government and was replaced by Jon Dahlberg, the new Area Manager. Citizen Members Jerry Sorensen and Colleen Allison resigned and were replaced through appointment by the governor by Art Vail of Whitefish and Dr. Paul Smiley of Columbia Falls. Dr. Loren Bahls, MDEQ representative, retired from state government and was replaced by Van Jamison. Dennis Christenson, Superintendent of the Hungry Horse Project, was transferred to the Washington, D.C. office of the U.S. Bureau of Reclamation and was replaced by Ralph Carter, the new Hungry Horse Superintendent.

Wade Fredenberg, United States Fish and Wildlife Service biologist, brings Commission members face-to-face with a Basin fishery issue during a Columbia Falls meeting.

"...encourage ECONOMIC DEVELOPMENT ... without compromising the present HIGH QUALITY of the Flathead Basin's AQUATIC ENVIRONMENT..."

Education, Information And Recognition

Emphasizing Education and Voluntary Participation

Public Education

Public education, one of the Commission's most important roles, is carried out in a variety of ways, including workshops, publications, awards and special projects. In addition to regular contact with the traditional print and electronic media and presentations, the Commission provides programs, on request, to schools and organizations. Those interested in learning more about the Commission and its activities are encouraged to schedule presentations designed for their particular needs.

Education activities include classroom presentations and field trips to observe water quality issues up close.

Watershed Workshop

The Commission participated in a six month-long planning process with other agencies, non-profit organizations and citizen volunteers to organize and conduct an interactive workshop on watershed issues in Kalispell. *The Power, Promise and Prospect of Water in the Flathead: What's The Role of Local Watersheds?* was conducted September 14, 1996 at Flathead Valley Community College. The Montana Watercourse, a Montana State University-based organization funded by MDNRC, provided technical assistance in organizing the event, drawing upon expertise developed through their successful Know Your Watershed workshop program.

The Flathead Conservation District, Natural Resource Conservation Service, Flathead Regional Development Office, Flathead Lakers, Citizens for a Better Flathead, Glacier Institute and other organizations worked with the Commission to devise a day-long event that would address the unique characteristics of the Flathead Basin and allow an opportunity to identify, explore and address issues at the local watershed level.

Participants were encouraged to contemplate and discuss three essential questions: what they value most in their watershed, what threats to those values could they identify, and what steps they could take to effectively address the threats? A key series of presentations focused on examples of how local individuals and organizations have identified water quality-related issues and have successfully taken steps to address them.

Over 80 area residents participated in the day-long event. In a follow-up survey conducted by The Montana Watercourse, seventy one percent said the workshop fulfilled its purpose "very well." In its own survey of workshop participants, respondents told the Commission that "population growth and accompanying increased human impacts" ranked as the greatest threat to water quality in the Flathead, and a variety of education initiatives were identified as the best way for the Commission to address such threats. Thirty seven percent of those contacted responded to the Commission survey.

Barbara Prescott of Lakeside leads a discussion of water quality issues at the 1996 Watershed Workshop.

Science Contest

In an effort to encourage scientific and literary investigation of Flathead Basin water quality issues, the Commission created a science contest in 1995, designed for public, private and home schooled students in grades seven through high school with categories for both science projects and written essays, creative stories or poems.

Cash awards totaling $400 annually are presented to the top three

entrants. Funding for the program is made available through contributions from individual Commission members, agencies, businesses and non-profit organizations. Copies of winning entries are available at the Commission office.

BasinWatch

The Commission's newsletter, BasinWatch, is produced quarterly and distributed to a growing list of recipients that includes volunteer monitors, media, public officials, legislators, agencies, schools, Commission members and the community-at-large. BasinWatch includes updates on Commission activities, details of volunteer and agency monitoring, information relating to a wide range of water quality issues, and guest contributions from scientists, agency representatives, volunteer monitors and others. Those interested in being added to the BasinWatch distribution list should contact the Commission office.

Commission member Rich May congratulates Flathead High School student Ian Paisley for his award-winning entry in the Commission's annual Student Science Contest. The contest encourages students throughout the Basin to work on projects related to the local aquatic environment.

FRP Map & Report

The Flathead River Partnership, an endeavor that began in 1993 with the signing of a Memorandum of Understanding among the Commission and a number of federal, state, tribal and local entities, was created to address a variety of issues associated with the main stem of the upper Flathead River. After a series of public scoping sessions in 1994, the Partnership created committees to address the top-rated issues identified through the public process.

The Partnership has evolved from an agency-driven initiative to one today largely citizen directed, with some ongoing agency support. The Partnership organized and conducted two successful "River Day" events designed to inform students and the public-at-large of river-related issues. The two activities, conducted on the Flathead River near Kalispell, involved the participation of agencies, non-profit organizations, the Montana Committee for the Humanities, and volunteers to organize and conduct a series of informative presentations on a wide variety of river-related issues. An estimated 600 students and adults attended the two activities.

With support from Flathead-area businesses and a grant from the National Park Service Rivers, Trails and Conservation Assistance program, the Partnership researched, wrote and designed a combination river users' map and "State of the River" report. The report updated the public and the Partnership on work in bank erosion, corridor development and recreation issues, cultural history, natural resources, geology and hydrology and agency/organization referral information.

Four thousand copies of the map/report were published. Distribution has been made to participating agencies, business funding partners, and the public-at-large. Additional copies are available at the Commission office.

The Flathead River Partnership's map and report provides a unique perspective on the main stem of the upper Flathead River.

FBC Brochure

The Commission's Education, Information and Recognition Committee collaborated on the design and contents of a much needed updated introductory brochure on the Commission, its structure, accomplishments and goals. Final design work and printing of the full color brochure was done in-house by Montana Department of Natural Resources and Conservation.

Awards

Through recognition of those who have taken out-of-the-ordinary steps to protect water quality in the basin, the Commission is instrumental in making the community-at-large aware of critical water quality issues and the innovative and effective ways in which they are being addressed by dedicated individuals and institutions.

In 1996, the Commission recognized "the extraordinary efforts taken by the City of Kalispell and the supervisor and staff of its Waste Water Treatment Plant to exceed standards established by the U.S. EPA" and awarded the city and its WWTP supervisor and staff a Commendation of Excellence.

The plant was also named recipient of the 1996 Regional VIII "Operation and Maintenance Excellence" Award by the U.S. Environmental Protection Agency. The state-of-the art plant routinely exceeds required levels of nutrient reduction and is credited with solving the basin's largest point source pollution problem.

"...international COOPERATION and COORDINATION between the State of Montana and Province of British Columbia..."

Bilateral Cooperation And Planning

Working Cooperatively to Monitor and Protect Our Water

Land Use and Population Trends

Population growth and land use trend factors often have a strong correlation with the presence or lack of good water quality. And, although point source pollution is no longer a major problem in the Flathead Basin, non-point source pollution is of significant concern.

Both Lake and Flathead counties, among the fastest growing in the state, continued to post significant population increases in the mid 1990s. The counties are among 12 in Montana that have registered a population growth of over 25 percent between 1975 and 1995.

In 1995, the last year for which there are reliable estimates, Lake County was estimated to have a population of 24,479, a 3.3 percent increase over the previous year.

Flathead County, meanwhile, had an estimated 69,512 residents, reflecting a 3.1 percent increase over 1995.

Nonpoint source pollution related to land use practices is a major threat to water quality in the Flathead Basin.

Both counties also show the continuation of a trend of the conversion of farmland to non-farm, primarily residential and commercial development. Flathead and Lake are among 17 counties in the state that have lost more than 10 percent of previously existing farmland between 1973 and 1992.

Such indicators as septic permitting and subdivision lot creation point to continued near record growth, although the numbers for most of the indexes in both counties are lower than in 1994, a peak year of the most recent growth cycle.

Lake County recorded 266 septic permits in 1995, down 23 percent from the previous year. Permits issued in 1996 totaled 173 in the first 10 months of the year. Lake County did record a major increase in subdivision lots created in 1995 — 208 compared to 120 in 1994 and 137 through September of 1996.

Flathead County tallied 728 septic permits in 1995, down 10 percent from 1994, while permits issued in 1996 reflected a further drop, totaling 648. Flathead County also saw a dramatic reduction in subdivision lots created, down 71 percent from 656 in 1994 to 189 in 1995. Subdivision lot creation experienced an increase in 1996, up 81 percent from 1995 to 342.

Land Use Planning Efforts

Flathead County suffered a setback in its attempt to implement an updated land use master plan when voters rejected the proposal in the June 1996 primary election. Despite the failure to establish innovative and comprehensive land use planning on a county-wide basis, several local communities carried out successful locally-based planning efforts, involving residents and such a major corporate entity as Plum Creek Timber and with technical assistance from the Flathead County Regional Development Office.

BC Land Use Plan

In October, 1996, British Columbia released the Implementation Strategy for the Kootenay-Boundary Land Use Plan, a multi-year, consensus-

Close cooperation with British Columbia remains a cornerstone of the Commission's role in the Basin.

building process that involved citizens, non-profit organizations, industry and government participation. Flathead Basin Commission representatives routinely attended sessions of the planning process, advocating for elements in the plan that would address water quality concerns in the headwaters of the North Fork. British Columbia has invited the Commission to review the Implementation Strategy and submit comments on it before its final review and approval.

Cooperation among U.S. and B.C. agencies and citizens on both sides of the border will assist the Commission in its efforts to protect water quality in the international North Fork of the Flathead watershed.

Coordination with British Columbia

A mutual interest in the cooperative management of the North Fork of the Flathead River led to an invitation from British Columbia for the Commission to participate in a day-long meeting of the Kootenay Inter-Agency Committee in Fernie, B.C. Organized as an information exchange to afford government officials, the public, agency representatives, and researchers to share data and points of view on a variety of natural resource and management issues in the international watershed, the session led to a higher level of understanding and a framework for ongoing communication and consultation among the participants. Plans were begun for a follow-up meeting in the U.S. North Fork in 1997.

British Columbia, Montana Cooperative Agreement

At the Commission's direction and through its role as representative of the Office of the Governor in coordinating natural resource issues with British Columbia, members Dennis McDonald, representing the B.C. premier, and Rich Moy, MDNRC Water Management Bureau Chief, collaborated on a draft Cooperative Agreement between the state and the province. The agreement, currently under review, would set up a framework to "promote and coordinate mutual efforts to ensure best management, protection, preservation and enhancement of our shared natural resources...for the benefit of current and future generations."

Under the draft agreement, the Commission and other entities from B.C. and Montana would become participants in a Cooperation Council, which would meet annually to monitor issues, establish sub-committees or task forces to address specific issues, and produce a biennial report.

Border Monitoring Station

International cooperation was the by-word in an ongoing effort to secure funding to relocate, install and resume regular operation of a water quality and quantity monitoring station at the U.S./B.C. border on the North Fork of the Flathead River.

The previous station, which had been in near continuous use since the late 1940s, was destroyed by flooding in June of 1995. The Commission's Monitoring Committee identified the re-establishment of the station as a priority for the Monitoring Master Program, and efforts commenced to obtain the needed funds.

Finally, in September 1996, the U.S. Congress, through the assistance of Senator Max Baucus and the U.S. Senate Committee on Environment and Public Works, authorized the expenditure of $50,000 to reconstruct the station. British Columbia pledged to designate an amount equivalent to 50 percent of the construction cost to fund the station's ongoing operation. The Commission is working with the U.S. Geological Survey and the U.S. Army Corps of Engineers to secure the federal appropriation and plan for the station's reconstruction at the soonest feasible date.

Replacing the flood-damaged border monitoring station is a Commission priority. The site will be used to collect water quantity and quality data of value to both Canadian and U.S. agencies.

Watershed Planning Stategy

The Next Big Step

To gain the support of the public and have the best chances of success, any effort to carry out comprehensive watershed planning must be based on current, scientifically valid water quality and quantity data and involve the widest possible base of affected individuals and entities.

Kalispell's state-of-the-art waste water treatment plant has been credited with dramatically reducing a major point source of phosphorus pollution in the Basin.

In response to the designation by the U.S. EPA of Flathead Lake as an impaired water body under Clean Water Act Section 303(d), the Flathead Basin Commission, in concert with the Confederated Salish and Kootenai Tribes, Montana Department of Natural Resources and Conservation and Montana Department of Health and Environmental Sciences (now Department of Environmental Quality), initiated the active phase of a long term watershed planning effort in 1994.

The two phase effort includes a technical assessment to locate non-point pollution upstream from Flathead Lake and an educational component to address the conclusions of the scientific phase and implement a voluntary, non-regulatory strategy to achieve U.S. EPA-established Total Maximum Daily Load (TMDL) levels for nitrogen and phosphorus entering the lake.

The technical assessment phase, now completed and scheduled for semi-final analysis in early 1997, was funded with a $150,000 U.S. EPA grant secured by U.S. Senator Conrad Burns, who designated the Flathead Basin Commission as the appropriate coordinator for the project. The educational phase, slated to begin in early 1997, is funded with a $100,000 DNRC Water Development and Renewable Resource Development grant approved by the Montana Legislature in 1995.

Technicians from the Confederated Salish and Kootenai Tribes use a bridge crane to collect water quality and quantity data on the Stillwater River near Whitefish. The multi-agency and volunteer effort identified sources of pollution upstream from Flathead Lake.

Broad-Based Involvement

To accomplish the wide range of data gathering necessary to identify nonpoint source pollution around and upstream from Flathead Lake, the Commission established a team of technical advisors, coordinated by Mountaintop Associates of Bozeman, to assist in the formulation of the data collection work plan, help identify sites for sample collection, and provide oversight of the process. Among those entities regularly participating in the technical committee included University of Montana Biological Station, CSKT, Flathead and Lake County Conservation Districts, Natural Resource Conservation Service, MDNRC, MDEQ, Flathead National Forest, Plum Creek Timber, Montana Logging Association, health departments of Flathead and Lake counties, Kalispell and Whitefish waste water treatment plants, and the Commission.

Specific components of the technical assessment phase include a watershed area assessment of the Flathead Lake shoreline for evidence of nutrient input from the area immediately surrounding the lake; synoptic analysis of nutrient contributions from selected Flathead Basin streams; an assessment of nutrient sources attributable to the air shed; and input from the Commission's ongoing Volunteer Monitoring Program.

The synoptic analysis phase — one day, multi-site surveys of streams from headwaters to outlet — was the most demanding aspect of the technical assessment, in terms of budget, coordination and human resources required. Under the direction of UM Biological Station researcher Bonnie Ellis, teams of technicians, researchers and volunteers collected water quality and flow data at over 100 sites on streams throughout the Basin, including the South Fork of the Flathead; the Stillwater, Whitefish and Swan rivers; Dayton, Stoner and Ashley creeks; and groundwater sources in the vicinity of Echo Lake. An additional component, coordinated by Mayre Flowers of Citizens for a Better Flathead and involving area high school science teachers and students, sampled urban storm water runoff during periods of heavy precipitation.

The synoptic process was conducted three times to capture essential water quality and discharge data in the sampled streams at optimum times of pre, peak and post runoff. UM Biological Station, CSKT, Flathead County Environmental Health, Flathead National Forest, and Plum Creek personnel, with the involvement of high school student volunteers, were instrumental in accomplishing the labor-intensive synoptic data-gathering.

For additional information on the Commission's watershed planning initiative, please request copies of Flathead Lake TMDL Work Plan and Flathead Lake Phase II Voluntary Nutrient Reduction Strategy, available at the Commission office.

Science students from all four Flathead County public high schools worked as volunteers with agency technicians and researchers to collect data for the Total Maximum Daily Load Study.

The Commission will work with the public, agencies and industry to reduce levels of phosphorus and nitrogen in headwaters streams through voluntary, non-regulatory means.

"...close **COOPERATION** and **COORDINATION** between federal, state, provincial, tribal and **local** resources and citizens."

"...to PROTECT the existing HIGH QUALITY of the Flathead Lake aquatic environment..."

Monitoring

Monitoring Master Program

Coordination of water quality monitoring in the Flathead watershed remains the Commission's most important role.

To achieve the highest level of ongoing water quality monitoring, the Commission adheres to the objectives set out in its Monitoring Master Program. The program is the result of technical input provided by researchers and technicians from cooperating agencies and the University of Montana Biological Station. The program sets out the following three general objectives:

A) Monitoring the water quality, quantity and aquatic life of Flathead Lake and its major tributaries.

B) Monitoring the water quality, quantity and aquatic life from representative catchments of the upper basin.

C) Monitoring bull trout populations and habitat in the basin.

Monitoring includes a wide variety of chemical and limnological parameters, discharge data, water temperature, elevation, fish populations, habitat and other relevant information. The goals are accomplished through monitoring of 12 sites to address Objective A, 34 sites for Objective B, and 19 sites for Objective C.

To date, the Commission's monitoring program has addressed only surface water. The likelihood of groundwater monitoring will be considered by the Commission after it is presented with a groundwater monitoring master program, currently being drafted by the Flathead Groundwater Coordinating Committee.

Monitoring Master Program Funding

The Commission works with a variety of participating agencies and non-profit entities that provide a variety of funding and in-kind support to achieve the program's objectives. Agencies and organizations contributing funds during the biennium included MDEQ, Flathead National Forest, Glacier National Park, Bureau of Reclamation, Flathead City-County Health Department, Montana Power Company, Flathead County, and Friends of the Wild Swan.

Contributions of in-kind services, including personnel and equipment, were made by Flathead National Forest, Glacier National Park, MDNRC, UM Biological Station and the Confederated Salish and Kootenai Tribes. CSKT agreed to provide trained staff and equipment necessary to begin regular monitoring of the Ross Deep site in Big Arm Bay on Flathead Lake and to assume Flathead Lake outlet monitoring at Polson previously done by UM Biological Station personnel.

Unfortunately, full funding for the Monitoring Master Program was not attained during the biennium, necessitating a reduction of monitoring frequency at a number of sites. In an effort to obtain the level of funding required to maintain the program at its intended level, the Commission has worked vigorously to secure additional financial contributions from a variety of local, county and tribal entities. The Flathead City-County Health Department became a new funding partner during the biennium.

Lynda Holmquist, Volunteer Monitor Coordinator, Dick McKay, Swan Lake Volunteer Monitor, and Brian Sugden, Plum Creek Timber hydrologist, are trained in the use of a dissolved oxygen meter by Bonnie Ellis, UM Biological Station researcher. Plum Creek and the Commission Volunteer Monitor Program cooperated on a 1996 DO study of Swan Lake.

Fisheries Mitigation

The cooperative agreement between the U.S. Bureau of Reclamation, Flathead National Forest, Montana Department of Fish, Wildlife and Parks and the Commission to facilitate funding for the improvement of the Hungry Horse Reservoir fishery entered its

final phase during the biennium. Designed to correct fish passage problems around the reservoir created by road construction, the program concluded with an estimated $45,000 savings out of the total BOR-funded budget of $125,000, attributable to the efficiency of and cost under-runs by project contractors.

The selective withdrawal device on Hungry Horse Dame became operational in August 1995, allowing operators to mimic natural temperatures in downstream discharges. River temperatures have been returned to the natural state, alleviating the sudden thermal spikes that had affected the downstream fishery and aquatic insect population.

Swan Lake Dissolved Oxygen Study

In an effort to document the availability of dissolved oxygen in Swan Lake, Plum Creek Timber and MDEQ researchers and Commission volunteer monitors undertook a number of measures to develop better information on the subject. In the summer of 1996, Plum Creek and a volunteer began conducting routine DO profiles in the lake's deep, southern depression near the inlet of the Swan River. In October, Plum Creek, MDEQ and VMP participants conducted a day-long survey of the lake, using two data-gathering teams and Global Positioning System technology to produce the first-ever dissolved oxygen profile of the entire body of water.

Results verify that, as previously believed, the absence of dissolved oxygen is confined to the deepest part of the southern-most portion of the lake. A detailed summary of the survey is available at the Commission office.

Volunteer Monitor Program

The Commission's Volunteer Monitor Program is an exemplary effort that combines citizen participation and low cost institutional support to provide ongoing water quality monitoring on lakes throughout the watershed. Of particular significance, in the case of all but three of the lakes (Flathead, Swan and Whitefish), the volunteer-produced data is virtually the only water quality information available. The program serves the dual purpose of fostering a stronger sense of stewardship among the volunteers and producing a dependable flow of accurate scientific information that is of value to the research community, a variety of public agencies and non-profit organizations, and the public.

The FBC Volunteer Monitor Program is the largest in the Northern Rockies. Volunteers collect data at 47 sites on 31 lakes in the Basin.

Now in its fifth year, the program involves the active participation of close to 50 volunteers who conduct routine monitoring activities on 47 sites on 31 lakes in Flathead and Lake counties. Since the program's inception in the fall of 1992, volunteers have filed 1089 monitoring reports. The program was the pioneer volunteer monitoring program in the state and remains one of the largest in the Northern Rockies. Volunteers have also participated twice in annual nation-wide monitoring exercises coordinated by Kent State University, helping provide an accurate picture of water quality in lakes coast-to-coast. The program also works in close coordination with a companion project administered by Region One MDFWP for lakes in Lincoln County, sharing training, newsletter distribution, data compilation and other common requirements.

The program added a number of new lakes in the biennium, including three in Glacier National Park monitored by Park Service personnel. In the coming year, the program will add additional lakes, including several in Lake County and the Jocko Valley on the Flathead Indian Reservation.

In addition to routine secchi disk (transparency), water temperature readings and meteorological observations, volunteers work with seasonal Commission staff to obtain chlorophyll a and total phosphorus data on an annual basis. During the biennium, the program began to record data profiles for participating lakes, utilizing equipment made available by MDEQ and Plum Creek Timber to document temperature, dissolved oxygen, pH and conductivity readings, adding further to the growing base of scientific knowledge about lakes throughout the watershed.

In 1995, the Commission published the "1992-1995 VMP Comprehensive Report," a compilation of data collected since the program's inception. Copies are available at the Commission office.

Volunteer Monitors work throughout the year to collect water quality data on 31 lakes in the Basin. Their efforts are an important contribution to the Commission's overall water quality monitoring strategy.

See page 37 for a comparison of Total Phosphorus and Chlorophyll a data collected by volunteers on Basin lakes.

Water Quality Monitoring Status Report

Executive Summary

This section of the Biennial Report summarizes current information pertaining to the overall objective of monitoring water quality in the Flathead Basin. The researchers involved in this monitoring process have not attempted to interpret thoroughly all the data in the water quality monitoring database. Rather, they have identified and analyzed key findings. A summary of key conclusions and recommendations is provided on page 34.

Under the guidelines of the Commission's Monitoring Master Program, researchers regularly collect data to establish baseline water quality conditions, to detect trends in water quality at selected sites, to detect and document sources and causes of water pollution, to measure the integrity of select biological communities by monitoring the habitat and populations of such indicator species as bull trout, and to develop predictive relationships between key hydrological, chemical, physical, and biological variables.

A primary goal of the Flathead Basin Commission is to identify existing or potential water quality problems in the drainage and determine the sources of pollution. A number of agencies and organizations work in cooperation with the Commission to monitor water quality and fisheries.

Background

Why Monitoring Water Quality Is Critical

What do people think of when they picture a land of pristine waters? Do they see themselves walking along cold, clear streams? Canoeing on a sparkling alpine lake? Reeling in a trout from the bank of a slow-moving river?

These images reflect various aspects of relatively pure water. Signs of declining water quality might reflect the opposite of such scenes: murky water in a stream, a lake choked with aquatic plants, or an angler unable to entice a fish to take a lure.

These examples relate to the "big picture" of water quality. However scientists measure water quality using specialized techniques and sensitive indicators. They monitor the amount of various chemical substances dissolved and suspended in water. They also check on such things as the condition of stream bottoms and lake shores, streamflow, water temperature, turbidity, sediments, and the clarity of water.

Since fish live in water, the same variables strongly affect them. Therefore researchers evaluate fish habitat quality by looking at the size and amount of fine materials in streambeds and the emergence success of fry from gravels. They analyze fish populations by measuring the number and size of fish and by counting redds (nests built by spawning fish). They also monitor zooplankton (minute animals eaten by fish) to determine their effect on fish populations.

The Flathead River Basin Environmental Impact Study, conducted from 1979 through 1983, gathered and analyzed data related to various aspects of water quality. The study concluded that waters of the Basin were generally very pure, but the study also documented a trend of declining water quality attributable to both human-caused and natural activities.

Only through continuous, coordinated, and properly conducted monitoring will researchers, government agencies, and the public be able to identify sources of pollution and have the scientific information available to help develop effective and responsible means to reduce or eliminate such threats to the Basin's enviable high level of water quality.

How the Water Cycle Works

Most water is retained in the Flathead drainage system for only a short period of time. The highest mountains in the Basin may receive 70 inches or more of precipitation annually, whereas valleys typically receive between 15 and 20 inches a year. Once precipitation reaches mountainous terrain, some of it will run off, some will evaporate, some will enter vegetation, and the remainder will percolate through the soil into the groundwater system. Much of the groundwater will eventually emerge as a spring or enter directly into a creek or lake.

Water remains in ponds and lakes for varying amounts of time. In deep lakes, water stratifies during the summer as the upper layer is warmed by the sun and the lower layer remains cool. The denser colder water may remain confined to the lower levels of the lake until late in the season when all lake water is likely to achieve the same temperature and result in a mixing of the previously stratified portions.

Water entering Flathead Lake through its tributary rivers and streams will remain in the lake for about three years before being discharged into the lower Flathead River at Kerr Dam. During that time, most of the suspended sediments will have settled out of the water and onto the lakebed. The result is cleaner water at the discharge point than at the several points where river and stream water is introduced to the lake.

Factors Influencing Basin Water Quality

Freshwater ecology is the study of animals and plants in relation to their aquatic environment. Lakes and streams in the Flathead Basin support many biological species, and this diversity reflects the generally pristine condition of the Basin's waters.

While the aquatic species of the Basin are notably unique and diverse, individual populations are not normally abundant. The generally sterile nature of the Basin's waters and the relatively short growing season limit population growth. Surface waters of the Basin contain relatively few essential plant growth nutrients (such as nitrogen and phosphorus). The shortage of such nutrients naturally limits the production of algae and other plants, which in turn limits the populations of fish and other aquatic animals that feed on them.

The naturally low productivity of aquatic plants and animals in the Flathead Basin is a direct result of the Basin's high water quality. Increases in productivity may indicate declines in water quality. The addition of even small additions of nutrients may result in the population explosion of aquatic plants and may encourage the proliferation of undesirable fish species.

Both natural and human-caused events can lead to the deterioration of water quality. Virtually all land use activities ultimately affect water quality. The nutrients in atmospheric deposition — pollutants introduced into surface waters through dust, smoke, rain and snow — are also believed to be a significant contributor to water quality problems in the Basin. Other key factors that influence water quality include water flow, water temperature, turbidity and sedimentation, water chemistry, and microbiology. For a thorough discussion of these factors, refer to Flathead Basin Commission Biennial Report, 1991-1992.

The Law and Water Quality

A wide variety of federal, state, tribal and local agencies have specific obligations to implement laws and apply regulations designed to protect water quality. A state permit system regulates point sources of pollution, such as discharges from municipal waste water treatment plants, while Best Management Practices (BMPs) are designed to control nonpoint sources of pollution (diffuse sources of pollutants resulting from natural occurrences and human activities over a relatively large area). Most water pollution in the Flathead Basin is attributable to nonpoint sources.

Laws and regulations that affect water quality in the Flathead Basin include:

- the Federal Clean Water Act and the Montana Water Quality Act,
- the Natural Streambed and Land Preservation Act (which regulates development activities taking place in streams and lakeshores),

• the Public Water Supply Law (which regulates logging and other activities with respect to their impact on water quality in watersheds used for public water supplies),

• the Sanitation in Subdivisions Act and the Subdivision and Platting Act (which together provide for state and local review of proposed subdivision),

• the Shoreline Protection Ordinance (which regulates certain structures, dredging, and filling below the high water mark on Flathead Lake and the Flathead River and its major tributaries within the Flathead Indian Reservation), and

• the Streamside Management Zone Law (which regulates timber harvesting activities adjacent to streams).

The Flathead Basin Commission supports agency enforcement of these regulations while encouraging agencies, corporate entities, and the public alike to assist in protecting water quality in the Basin through a variety of non-regulatory, voluntary means.

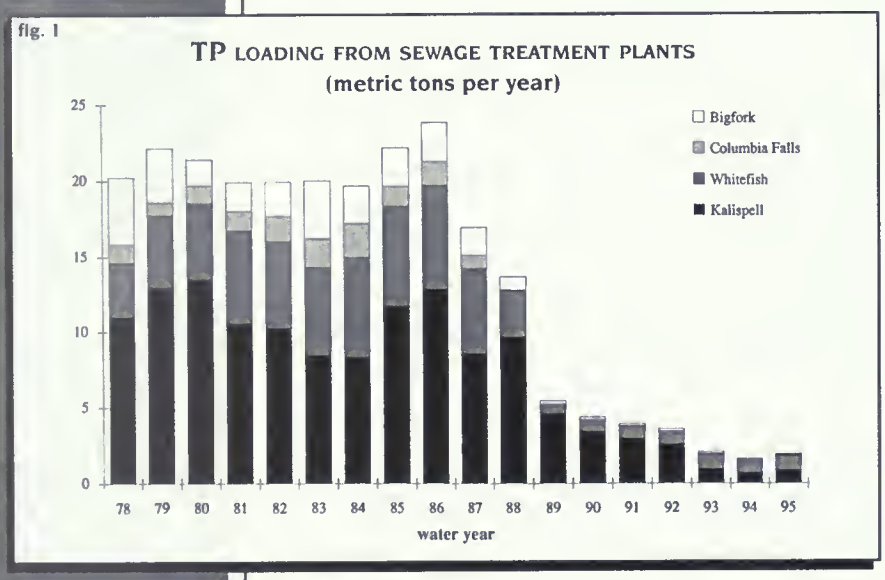
Water Quality in Flathead Lake and Its Tributaries

For almost two decades water quality conditions in Flathead Lake have been monitored by personnel of the University of Montana Flathead Lake Biological Station. The monitoring program was based on limnological principles that clearly show that long-term sustainability of water clarity and purity in lakes is directly related to the input of the primary plant growth nutrients, phosphorus (P) and nitrogen (N). If human activities accelerate the input of N and P beyond specific thresholds, water quality can be degraded very rapidly as a consequence of scum and odors associated with blooms of algae and bacteria. The monitoring program therefore emphasized measurement of N and P loads as drivers of algal production (measured as phytoplankton primary production, PP), algal standing crop biomass (concentration of chlorophyll *a*, chl*a*) and water clarity (secchi depth). Monitoring began in 1977 and is an ongoing program (Flathead Basin Commission 1983).

Gains in P and N Control

Early in the monitoring program, it became apparent that urban sewage treatment plants upstream from the lake were major anthropogenic sources of labile N and P. At the time (1983) it was thought that the lake was more sensitive to P than N loading and a control program for P was implemented (Water Quality Bureau 1985). Phosphorus in point source sewage discharges is highly available to algae for growth. New technologies to control P were implemented at most of the urban sewage treatment plants (STPs) in the basin, and a basin-wide ban on the sale of P containing detergents was enacted. As a consequence of these management actions, P discharge from the STPs has declined substantially in recent years. Indeed, the percent of the total load of phosphorus from STPs to Flathead Lake declined from over 20 percent in 1978 to less that 5 percent since 1989 (see Figure 1 for metric tonnage).

fig. 1

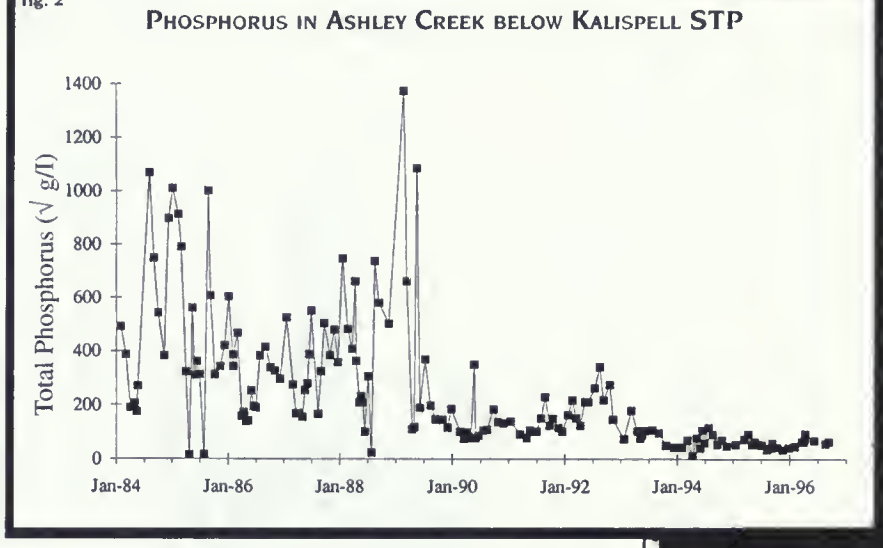


Further Control Measures

Later studies showed that during the late summer algal production in the lake was controlled by the supply of both N and P. While not required by the state, two of the municipal waste treatment facilities have taken steps to control nitrogen. Kalispell

voluntarily instituted active nitrogen treatment as a preventative measure, in addition to ammonia controls to prevent toxicity problems in Ashley Creek. The recent expansion of the area of coverage by the Kalispell STP to include Evergreen was also important in reducing a significant source of nutrients to Flathead Lake. The Somers-Lakeside community system discharges the effluent on land such that no direct discharge of N or P to the lake occurs. However, concern for the future of water quality in the lake remains, because inputs of N and P from diffuse (non-point) sources are usually associated with the rapid increase in population and economic activity. Since population growth in the Flathead Basin has been close to three percent per year during the monitoring period, non-point sources, coupled with increasing volume of sewage reaching the plants, could offset the conservation gains made by upgrading the sewage treatment plants.

fig. 2



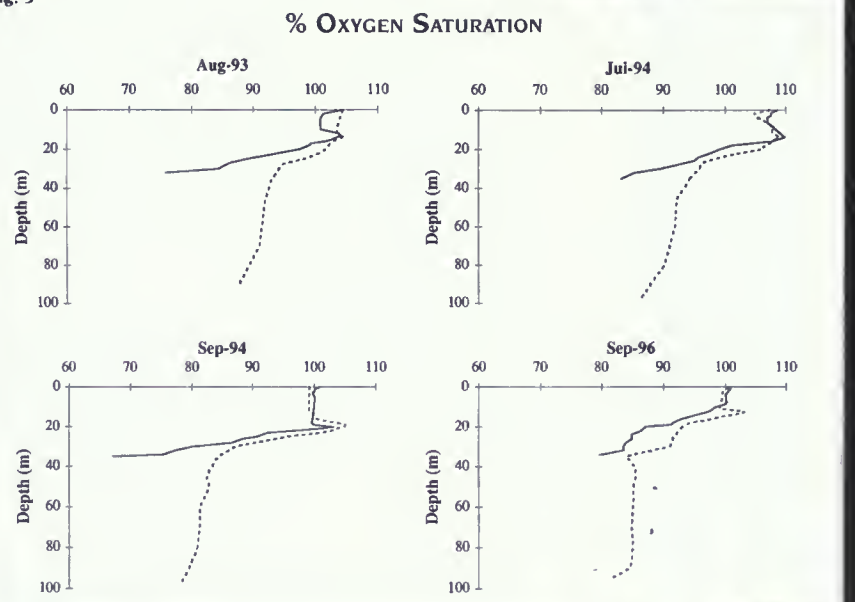
Nutrient Loading to Ashley Creek

Phosphorus and nitrogen loading to Ashley Creek from the Kalispell sewage treatment plant was very high prior to 1989; thereafter concentrations of phosphorus decreased (Figure 2) in response to the phosphorus ban and better technology at the treatment plant. Researchers have examined sediments from Ashley Creek below the Kalispell STP and discovered that they have the potential (under the right conditions) to release massive amounts of N and P. It is very important that the creek remain oxygenated (by eliminating pollution sources above the effluent from the Kalispell STP) so that the major load of phosphorus remains adsorbed to the sediments.

Phosphorus Retained

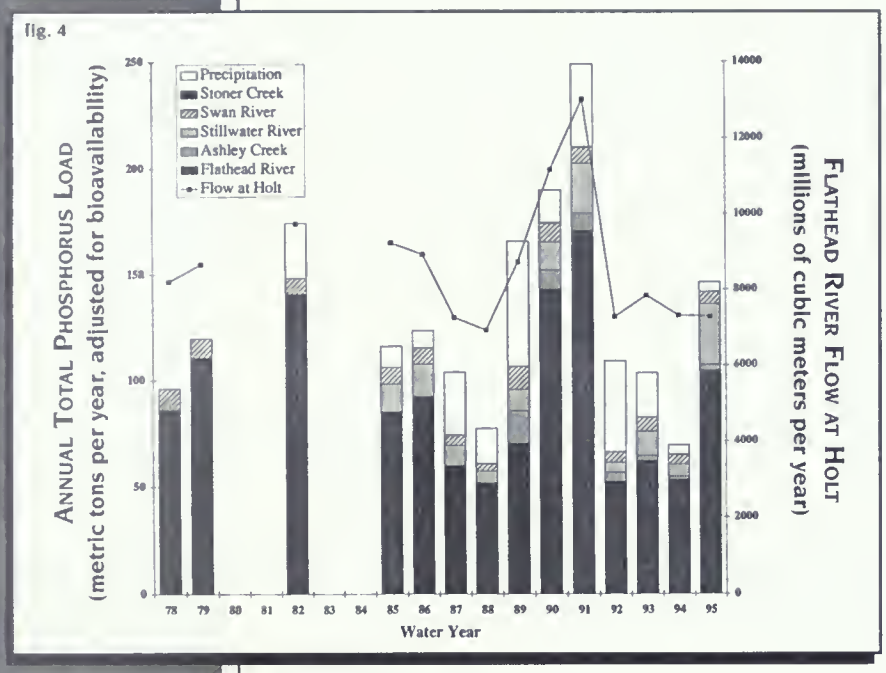
In the analysis of nutrient inputs and outputs to Flathead Lake researchers found that over half of the incoming load of phosphorus each year was retained in the lake, stored in the bottom sediments. The phosphorus is held there by the oxygenated water column. Should the water column above the sediments become de-oxygenated, a substantial amount of the stored phosphorus would be released back into the lake and water quality would decline precipitously. Previous studies (1991 through 1993) documented a significant dissolved oxygen sag at the Ross Deep site in Big Arm Bay during the late summer, which occurred nowhere else in the lake, and, to our knowledge, dissolved oxygen values at these levels were never previously reported for Flathead Lake. Although funding does not allow continuous monitoring of Ross Deep, a few measurements made since the early study indicate that the problem continues (Figure 3).

fig. 3



Oxygen Deficit

Increased nutrients (P and N) from shoreline pollution sources and nutrients carried into the bay by Flathead River currents during spring runoff are possible causes of the oxygen deficit in Big Arm Bay. Increased nutrients result in more plant and animal growth, and as this organic matter falls into the deeper waters, it is broken down by bacteria, which use up oxygen in the process. The more organic matter present, the more



that is available for metabolism by the bacteria and the greater the oxygen consumption. Native trout need relatively high levels of oxygen to be healthy (about 7 mg/l) and at Big Arm Bay concentrations were less than that. Routine monitoring in those parts of the lake that appear to be changing is important. Because bays are shallower and tend to trap nutrients, they may show signs of deterioration before the midlake site.

Sources of Phosphorus

In all years the Flathead River has been the largest contributor of bioavailable phosphorus to Flathead Lake (Figure 4). However, both wet and dry atmospheric deposition (dust, smoke and other airborne contaminants that fall directly on the lake) are a significant source of phosphorus to the lake (10 - 38 percent of the total mass input). Contrary to river input, which occurs predominantly in the spring runoff period, sporadic events producing deposition occur year around (though peak phosphorus inputs are common in both spring and fall). While river inflow occurs at the north end of the lake, phosphorus input via the airshed occurs lake wide. The percentage is high relative to other studies, but not surprising given the high level of airshed particulates in the valley. The American Lung Association recently cited Flathead County as one of 16 counties in the U.S. violating federal air pollution standards (PM-10 fine particulate pollution) during 1992.

Shoreline Sources of Nutrients

Stoner Creek, the largest shoreline tributary, was not a significant source of bioavailable phosphorus on a lake wide basis (Figure 4). However, nutrient loads in Stoner Creek were very high relative to its volume, suggesting possible land use problems in the watershed. Loads from other lake shore sources were insufficient for inclusion in the calculations of phosphorus flux. However, inputs of available forms of phosphorus and nitrogen from shoreline sources, while small in comparison to lake wide mass flux, do produce localized bursts of bioproduction, particularly in the form of algae on rock surfaces. Indeed, on several instances sewage breakouts have been discovered by presence of these mats of algae. Shoreline nutrient pollution is a problem in Flathead Lake in some areas, such as Big Arm Bay, and should not be trivialized by the fact that shoreline sources of bioavailable phosphorus are very small in terms of whole lake flux. Moreover, shoreline algal mats in Flathead Lake are limited by the quantity of phosphorus in the water column, thus we would expect an increase in the growth of these algae with increased phosphorus. An often-expressed complaint by long time shoreline residents is that the "ring around the lake" formed by algal growth is significantly more visible in the last decade. Data on the growth of algae along an undeveloped shoreline of Flathead Lake were first collected in 1988. Additional data were gathered from 10 sites located in developed bays or regions in 1996. These data will provide a solid baseline for future monitoring of the "ring around the lake."

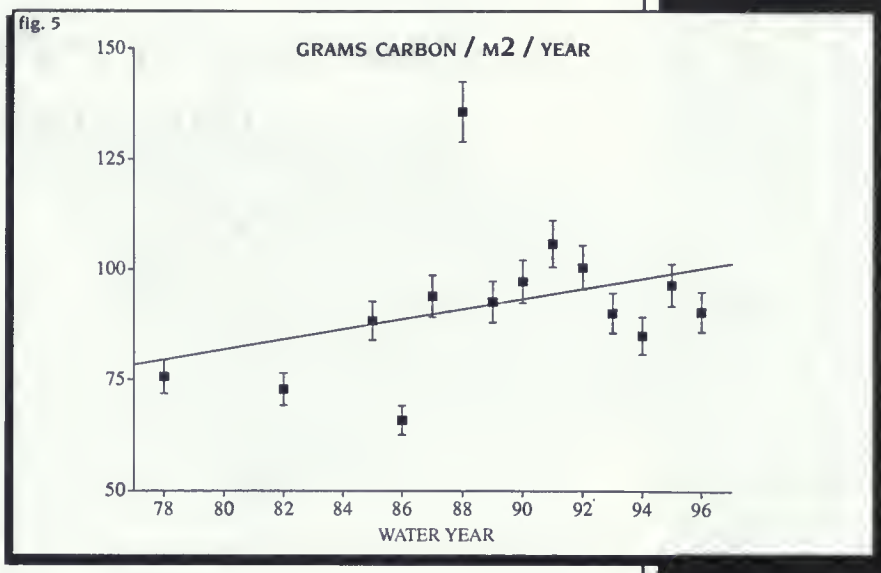
Primary Productivity

The main indicator of water quality in Flathead Lake is primary productivity, the ability of the lake to produce algae. Unfortunately, due to a lack of funding in 1996 primary production was not determined during July and August (the primary growing season). July and August values were estimated by averaging values for those months from the previous two years. Thus, the 1996 mean may well be underestimated as summer temperatures and light levels were lower in 1994-95 than in 1996.

Relation to *Mysis*

Although no large increases in primary production have been observed since 1988, the mean value for 1995 was greater than the previous two years (Figure 5). The data may reflect a re-balancing of the lake's food chain disrupted by the establishment of *Mysis* shrimp in the 1980s. The shrimp eat tiny crustaceans, which eat the algae. The reduction in the number of crustaceans can lead to an increase in algae, potentially increasing primary production. Levels of *Mysis* peaked in 1986 and then declined dramatically and appear to have stabilized somewhat (Figure 6). The mean density of *Mysis* in 1994 was 26.3 shrimp per square meter, but numbers rose again in 1995 to 42.0 per square meter, the highest density recorded since 1988. Researchers believe that the density of *Mysis* shrimp will continue to oscillate as the food web continues to change. If another exotic species is introduced into the lake or if anglers over-harvest one of the sport fishes, *Mysis* shrimp densities may fluctuate dramatically again. See the Flathead Basin Commission 1991-1992 Biennial Report for additional information concerning the introduction of *Mysis* and its effects on the lake food web.

fig. 5



Other Primary Production Influences

Primary production in Flathead Lake may also be influenced by other processes, such as the pattern and timing of water delivery to the lake through the operations of Hungry Horse and Kerr dams in the 1990s, the depth and duration of the mixed layer of the lake in relation to patterns of temperature stratification and seasonal or shorter term dynamics in bioavailability of phosphorus, nitrogen and inorganic carbon in relation to photosynthetically active radiation. These are some of the more important processes that continue to be quantitatively examined by researchers at the University of Montana Flathead Lake Biological Station.

Figure Legends

Figure 1. Total load of phosphorus from sewage treatment plants to Flathead Lake (in metric tons per year).

Figure 2. Concentration of total phosphorus (micrograms per liter) in Ashley Creek downstream from the Kalispell sewage treatment plant effluent.

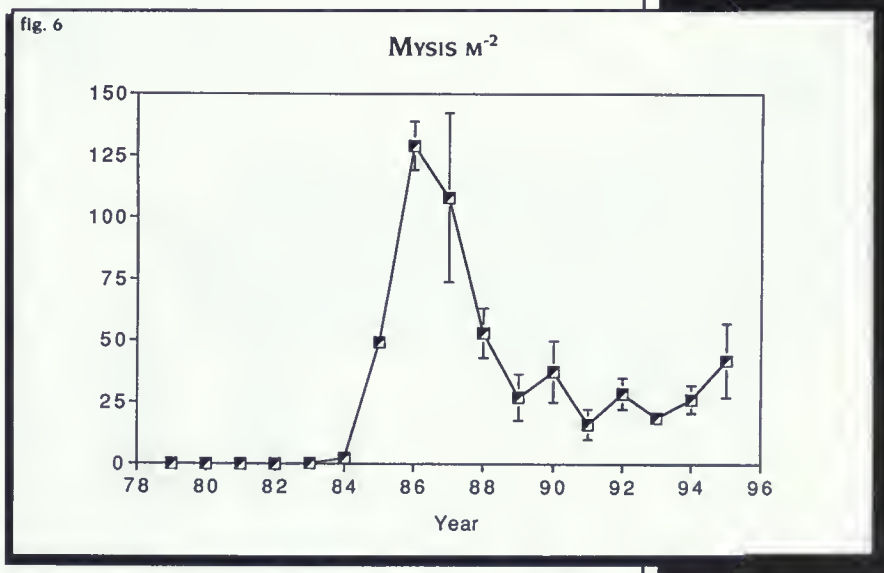
Figure 3. Percent of oxygen in the water column of Flathead Lake at the Ross Deep site in Big Arm Bay (solid line) compared to the long-term monitoring site at midlake, west of Yellow Bay (dotted line).

Figure 4. The mass of biologically available phosphorus by source (histograms) reaching Flathead Lake annually in relation to annual inflow from the Flathead River (closed squares).

Figure 5. Mean annual pelagic primary productivity (the ability of the lake to grow algae) for Flathead Lake.

Figure 6. The mean density of *Mysis* shrimp since its introduction into the Flathead Lake watershed.

fig. 6



Water Quality in Headwater Streams (National Forests)

Background on Monitoring

Cooperative Effort

The cooperative effort to monitor water quality across a variety of headwater streams, lakes and the North and Middle forks of the Flathead River reported here was initiated in 1994 and continued through 1996. This effort was conducted under the auspices of the Monitoring Master Plan of the Flathead Basin Commission and co-directed by the Flathead National Forest, Glacier National Park, and the University of Montana's Flathead Lake Biological Station. Consortium funding was provided by the Forest Service, Park Service, the University and the private conservation group, Friends of the Wild Swan.

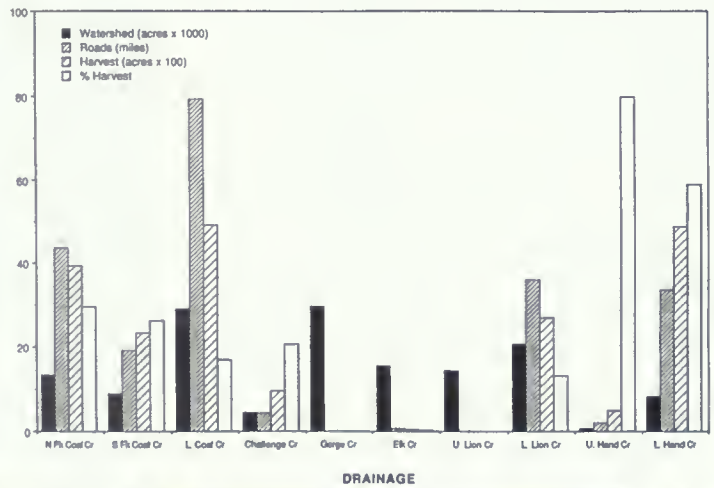
Monitoring Focus

Similar in principle to the water quality monitoring on Flathead Lake, headwater monitoring focused on sediment, phosphorus (P) and nitrogen (N). Increased sediment, phosphorus and nitrogen concentrations are often an indicator of water quality degradation. Fine sediment, composed of small organic and inorganic particles, directly affects fish reproduction by filling spawning gravels and cobble. This has been shown to impact spawning success of many fish species, especially native bull trout and west slope cutthrout trout. High sediment concentrations may indicate a variety of upstream disturbances, such as streambank erosion, slumping, or runoff from roads. These disturbances may be natural or may be related to man's land-use activities, or both. Fine sediment also directly affects water clarity of downstream lakes and nutrient loads in both streams and lakes. Although nitrogen and phosphorus are essential for plant growth, when in high concentrations these nutrients result in blooms of algae and bacteria choking streams and causing noxious scum and odors in lakes.

Monitoring sites

The headwater stream monitoring was directed toward watersheds from different geographic areas of the Flathead Basin, different stream sizes, and different levels of land management activity. Thus, these streams may exhibit a variety of natural and land-use related sediment and nutrient levels. Figure 1 displays several watershed and land-use attributes of the ten headwater stream sites reported here. Three monitoring sites, the North Fork, South Fork and Lower mainstem of Coal Creek in the North Fork Flathead drainage, have had timber harvested on 20-30 percent of the land within their watersheds since the early 1950s (see Figure 2).

fig. 1

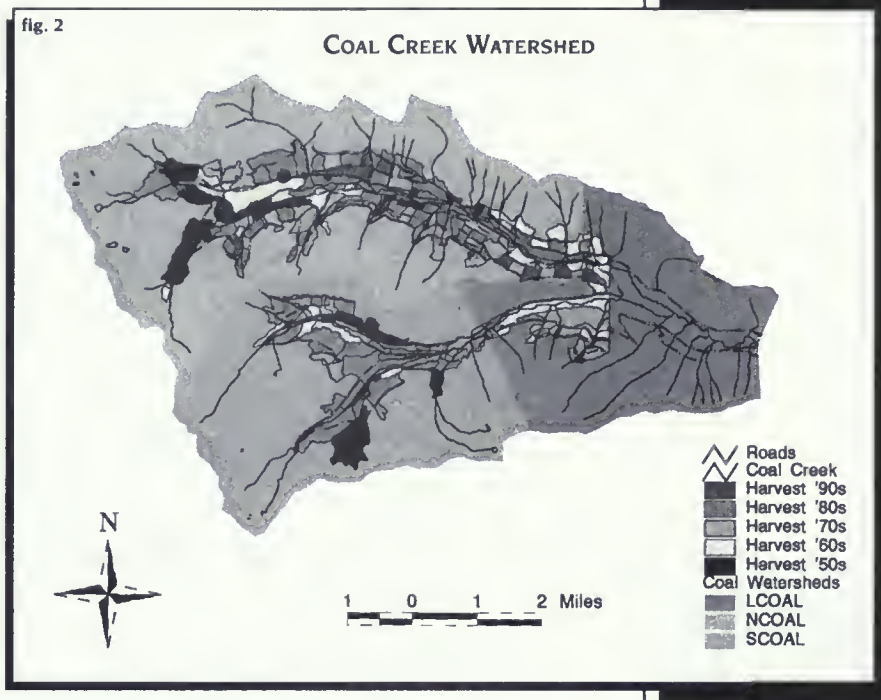


Challenge Creek, in the Middle Fork Flathead drainage, was one of the smaller watersheds in the monitoring array. Similar to the Coal Creek drainage, the Challenge Creek watershed has had timber harvested on about 20 percent of its area in the past 25 years. Gorge Creek, in the South Fork Flathead drainage, flows from the largest and most remote of the monitored watersheds. Gorge Creek, being within the Bob Marshall Wilderness, has no roads and no timber

harvest. Elk and Lion Creeks, in the Swan drainage, have experienced little or no road construction and no timber harvest in the upper portions of their watersheds, but as seen in Figure 1 and Figure 3, extensive roading and timber harvest has occurred in the lower portion of the Lion Creek watershed.

Hand Creek, in the Stillwater drainage, was distinctly different from the other watersheds. The upper monitoring site on Hand Creek drains a small section of the watershed (612 acres), but has experienced timber harvest over 80 percent of its area. Also, in 1995 the Little Wolf Fire burned about 50 percent of the Hand Creek watershed which prompted the addition of the Lower Hand Creek site to the array of monitoring stations. Similar to the upper portion of the watershed, the lower Hand Creek watershed has been extensively harvested (see Figure 1).

fig. 2



Purpose of Monitoring

The purpose of the monitoring was: 1) to establish an array of headwater sites that represented different geologic-geomorphic regions of the basin, 2) to select watersheds that had distinctly different levels of forest management activity, thus allowing land-use comparisons, and 3) to establish baseline data for long-term monitoring. Although funding constraints did not permit all sites to be sampled all years, the data did allow several years of cross-watershed comparison.

Stream Discharge and Material Transport

Water Flow

Watersheds receive, collect, and discharge water. The volume and timing of water flow, as well as the quantity of soluble and particulate elements transported by the water, vary between watersheds and vary between years within watersheds. All the monitored streams are "snowmelt driven," receiving their highest flows during spring snowmelt. Generally, low flow or "base-flow" conditions are expressed by these streams in late summer, fall and winter. Particles and dissolved nutrients transported by these streams are affected by a multitude of factors such as stream gradient, stream volume, erosive stream-power, overbank flow, overland flow from uplands, availability of material for transport, and land-use within the drainage, to name but a few.

fig. 3

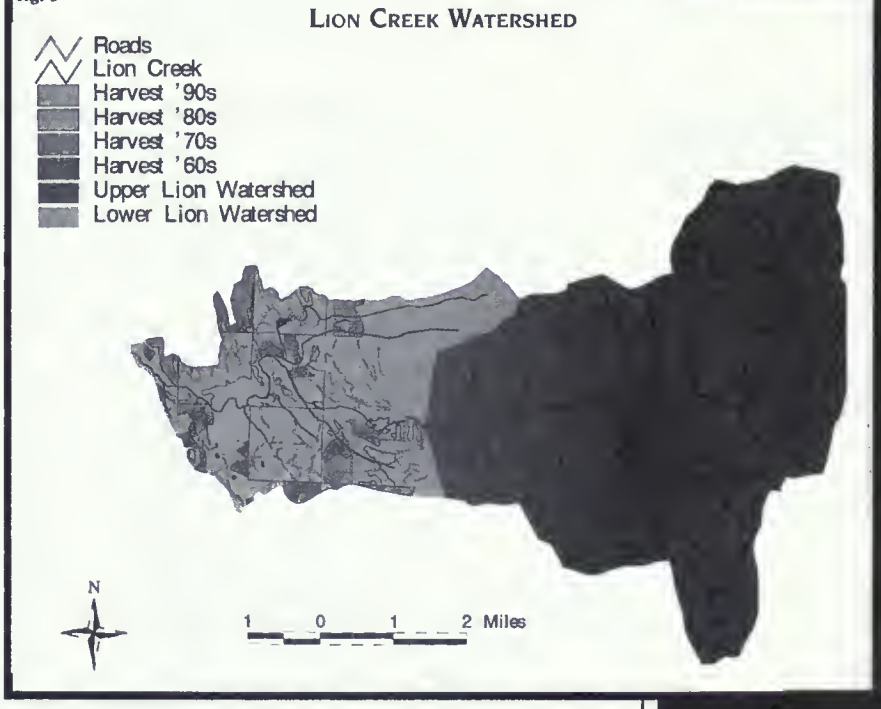


fig. 4

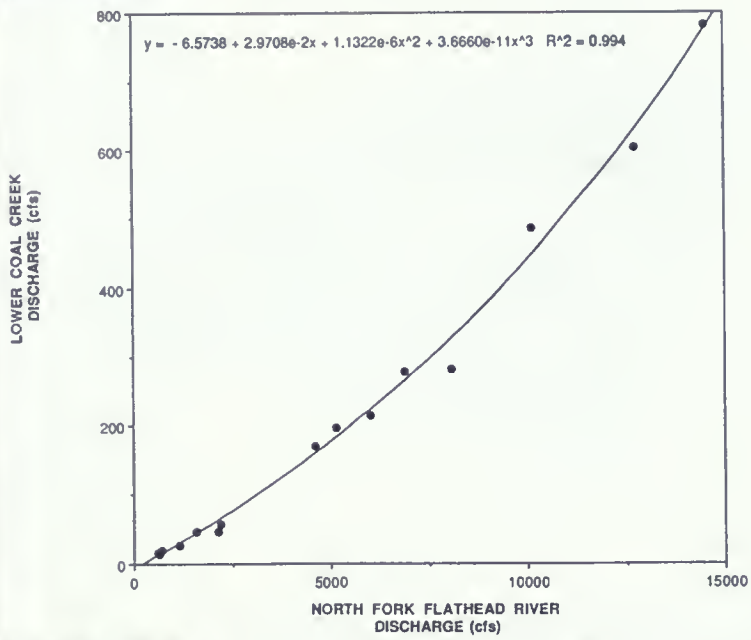


fig. 5

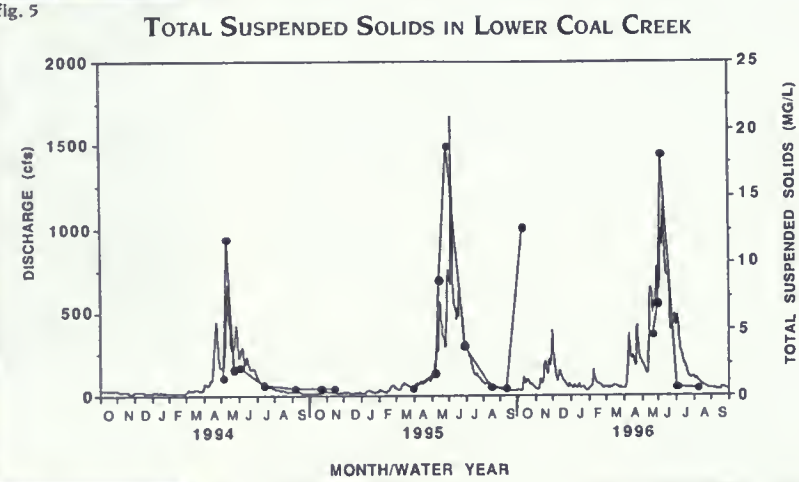
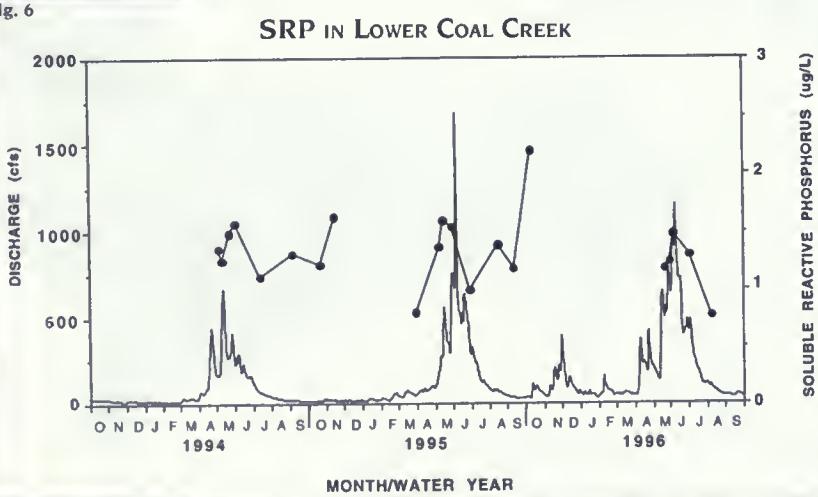


fig. 6



Measurements

Only Hand Creek of the monitored streams had continuously recording, year-round discharge gauges, although such data are essential to making calculations of material loads coming from a watershed. In this analysis, single-point discharge measurements were made at each monitoring site each sample date. These data were referenced (regressed) against the continuous flow measurements at USGS gauges on the corresponding mainstem tributary river downstream. For example, Figure 4 displays the regression points and equation (third degree polynomial) for estimating discharge of Lower Coal Creek. The equation describes the relationship between the known discharge in the North Fork Flathead River and spot-measures of discharge at the Lower Coal Creek monitoring site throughout the monitoring period.

Discharge and TSS

The concentration of fine particles transported by streams (i.e. total suspended solids, TSS) is often closely correlated with stream discharge because high flows are naturally erosive. In Figure 5, for example (again on Coal Creek), a strong relationship between discharge and TSS is apparent. Each year of the monitoring, as stream discharge increased during spring snowmelt, the concentration of particles being transported by the stream increased. In 1994 the peak of spring runoff was less than half that of 1995 or 1996. Correspondingly, TSS concentrations were lower in 1994 than in 1995 and 1996. The high TSS concentration in October 1995 was in response to increased discharge from unusually heavy autumn precipitation that continued throughout November and December.

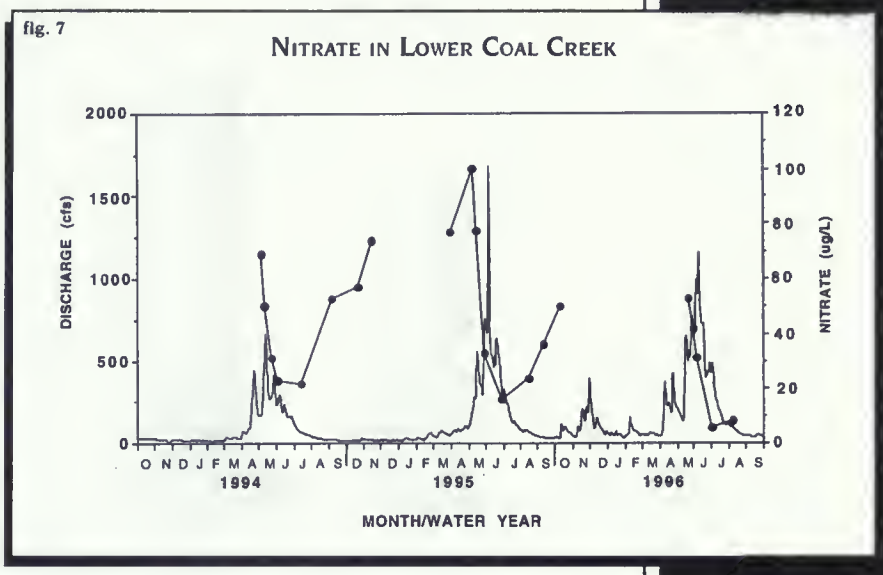
Dissolved Compounds

Concentrations of dissolved compounds may or may not follow the stream discharge cycle. For example, Figure 6 displays the concentration of soluble reactive phosphorus (SRP) over the monitoring period. Unlike TSS, SRP concentrations in Lower Coal Creek did not vary significantly with increased discharge, but remained between 0.7 and 2.1 mg/L among all sample dates. Nitrate concentrations at the Lower Coal Creek site provide an excellent example of a very complex transport pattern (Figure 7).

Nitrate Concentrations

Nitrate concentrations in streams are frequently affected by groundwaters, which often contain higher concentrations of nitrate than surface waters. Note that nitrate concentrations were relatively high during the rising hydrograph of each spring runoff cycle. Nitrate concentrations then decreased during peak runoff, continued to fall during the declining portion of the discharge curve, but increased again during base flow. This pattern is characteristic of groundwater effects during the early snowmelt period, dilution of nitrate as snow melts rapidly during and immediately after peak discharge, then a return to higher nitrate concentrations during base flow.

fig. 7



Analysis of Land-use in Relation to Particulate and Solute Loads

Gorge, Coal and Challenge Creeks

Figure 8 displays the annual water yield, TSS load, and TP at each of the sites monitored. Note that Gorge Creek, the wilderness drainage and largest of the watersheds, had the highest water yield, but also had comparatively low TSS and TP loads. In contrast Lower Coal Creek, the similarly sized drainage in the site array, with nearly 80 miles of roads and 5000 acres (i.e., about 17 percent of drainage area) of timber harvest, had over twice the TSS load and nearly 3x the TP load per area. Similar to the three Coal Creek sites, Challenge Creek demonstrated relatively high levels of TSS and TP loadings, particularly on a per area basis. Also like the Coal drainage, Challenge Creek watershed has experienced timber harvest over more than 20 percent of its area. Challenge Creek has several exposed banks along its lower reaches that are mast wasting, which may account for a significant portion of these loadings. These exposed banks are thought to be natural; however, it is unclear if water yield or regime changes associated with management are playing a role in the rate of stream bank losses.

Lion and Elk Creeks

A similarly interesting comparison comes from Lion Creek. The Upper Lion watershed remains in a near pristine condition, but the lower portion of the drainage has been heavily timbered with accompanying road construction (see Figures 1 and 3). Note that in Figure 8, water yield was nearly

fig. 8

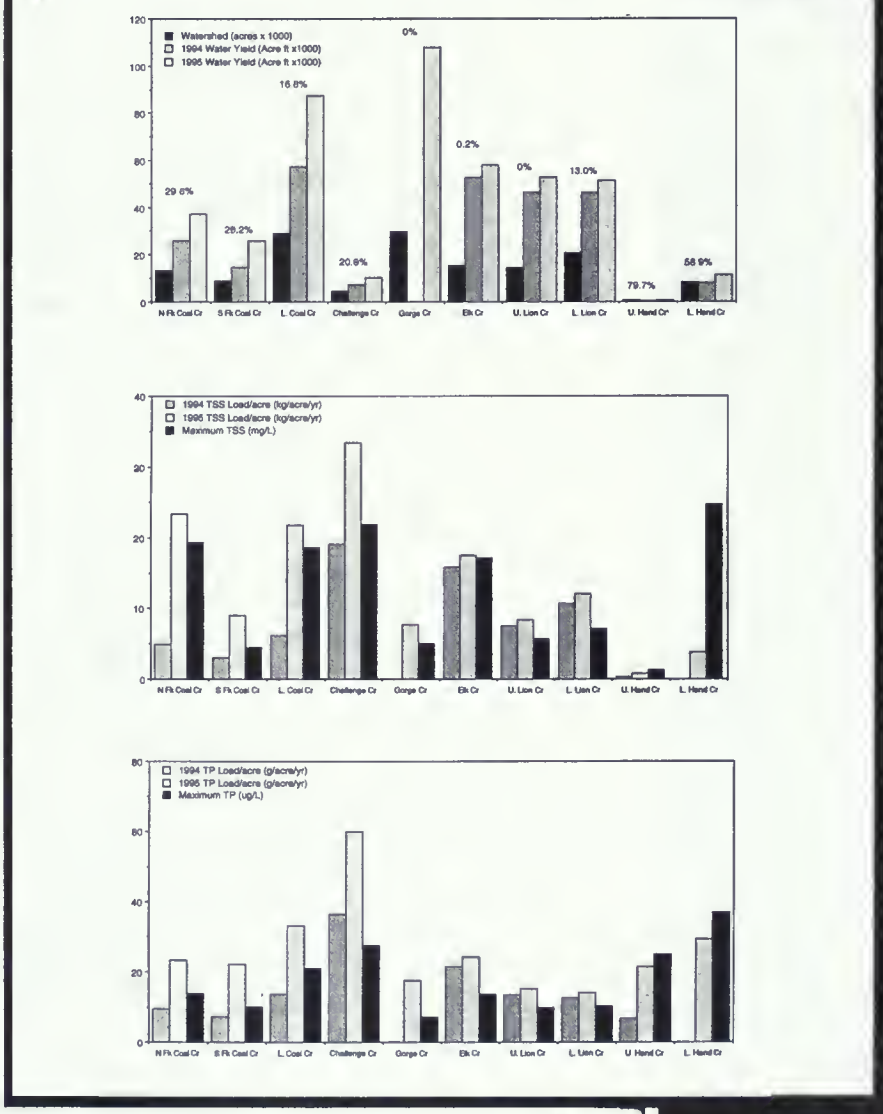
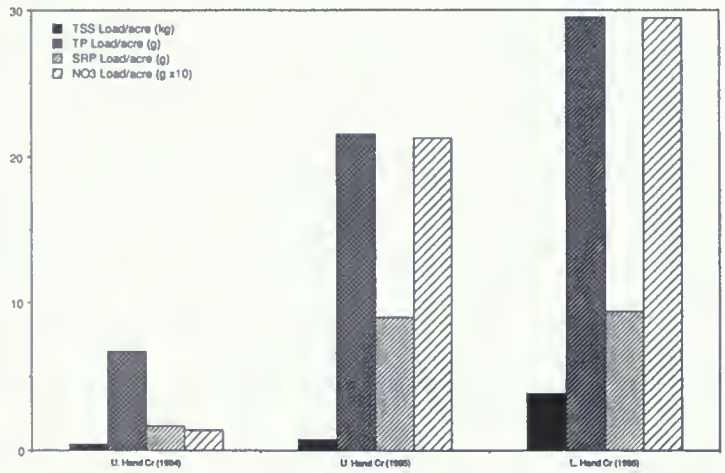


fig. 9

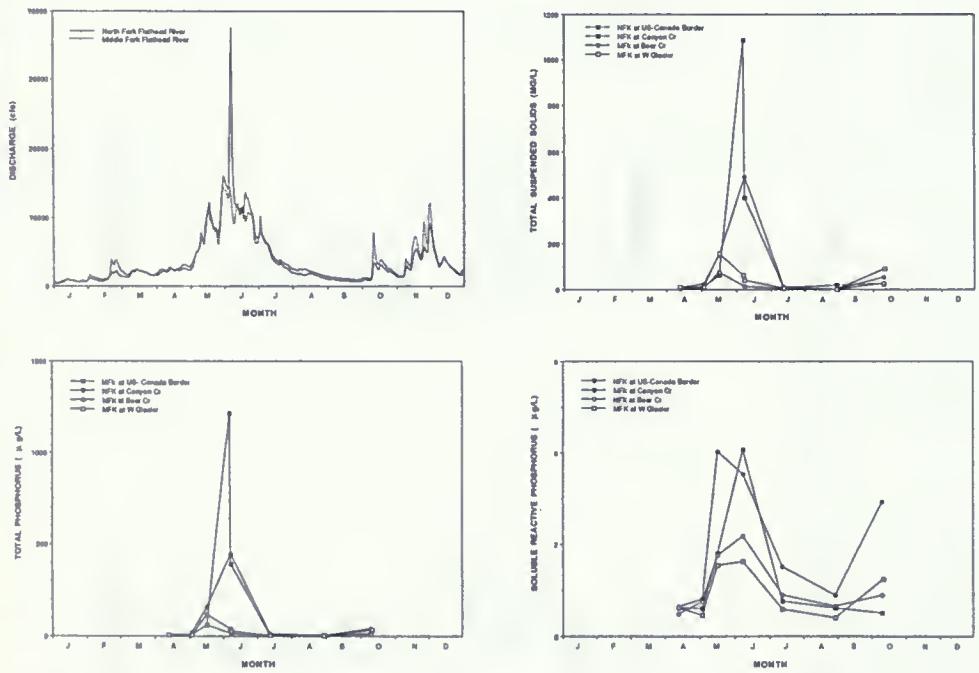


identical at the two sites, but the TSS load was about 60 percent higher at the Lower Lion Creek site than at the Upper Lion Creek site. Clearly, TSS load increased significantly even though water yield was not significantly different. This may be particularly poignant since the lower portion of the Lion Creek watershed is an area considered to be at low risk of sediment routing to the stream. Similar to TSS, total phosphorus load increased at the Lower Lion Creek site by approximately 20 percent above that of the Upper Lion Creek site. These interpretations, however, may not be completely straightforward when compared to Elk Creek. Although the Elk Creek drainage has had very little management activity, TSS and TP values were much higher at either of the Lion Creek sites. This demonstrates some of the natural, inherent differences between watersheds. Also of note, we observed slightly increased TP values in summer 1996 in Lion Creek coincidental with a small prescription burn in the upper Lion Creek basin. This observation is consistent with research conducted on the Red Bench Fire and the monitoring on Hand Creek.

Hand Creek

Upper and Lower Hand Creek sites also show land-use disturbance and its effect on nutrient loads. The Hand Creek watershed was the most heavily timbered of all the monitored drainages (see Figure 1). The small Upper Hand Creek watershed has experienced harvest over nearly 80 percent of its area while the drainage as a whole has experienced timber harvest over nearly 60 percent of its area. This is partly the result of salvage logging after the Little Wolf Fire that occurred in late summer 1994; however, this drainage was heavily harvested prior to the fire as well. The Hand Creek watershed has relatively low elevation headwaters and mild stream gradient, both reflected in low TSS loads (Figure 9). But, note that TP, SRP and nitrate increased significantly in 1995 over 1994 at the upper site. This was particularly true of nitrate, which increased by more than 10x in total load between 1994 and 1995. These high nutrient values were also observed in water year 1995 at the Lower Hand Creek site. These data underscore the vulnerability of watersheds to significantly increase export of nutrients following wildfire.

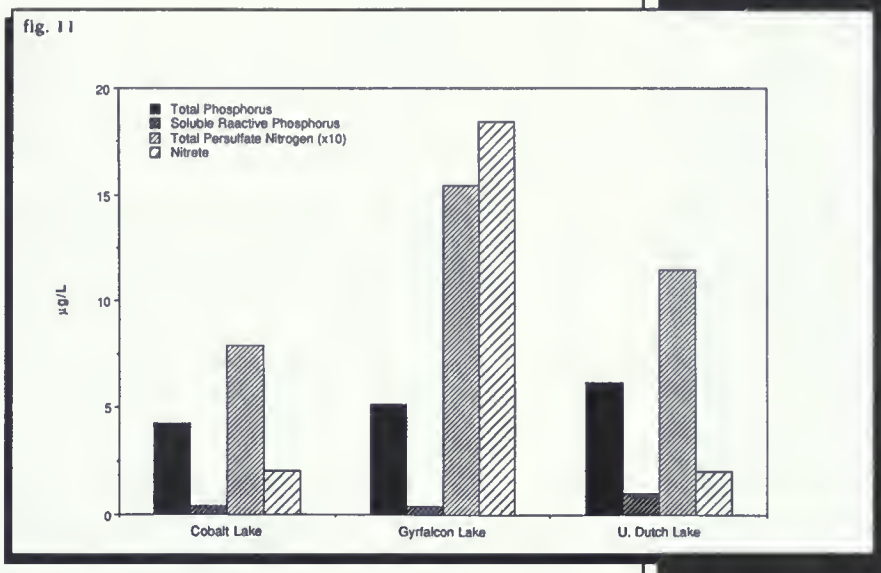
fig. 10



Tributary Rivers

The North and Middle Forks of the Flathead River were sampled in 1995. The North Fork was sampled at the US-Canada border and at the USGS gauging site

near Columbia Falls. The Middle Fork was sampled above the confluence of Bear Creek and at West Glacier. Funding limitations only permitted one year of monitoring during this reporting cycle.



In early June 1995, the North Fork of the Flathead River experienced its highest discharge in 30 years. This flood was the result of isolated, but heavy rains along the continental divide in Glacier National Park. The rains fell on melting snow at high elevation, particularly tributaries of the North Fork. As seen in Figure 10, the North Fork experienced a discharge approaching 40K cfs. In contrast, Middle Fork discharge did not exceed 15K cfs during that same period. The significantly different discharge regimes of the North and Middle forks were also reflected in significantly different sediment and nutrient concentrations during the flooding. Note that although TP concentration in the North Fork exceeded 1000 mg/L, SRP concentration at the same time was only about 4 mg/L. By contrast, during base flow conditions SRP constitutes about 10 percent of the total phosphorus concentration. The extremely high TSS and TP values during the North Fork flood and the comparatively much smaller increases in SRP illustrates how tightly phosphorus is chemically bonded to soil particles. This relationship is very important to Flathead Lake and that portion of the TP load that eventually becomes available to biological activity.

Alpine Lakes in Glacier Park

Three alpine lakes in Glacier National Park were sampled during the monitoring period. Phosphorus values, both TP and SRP, were extremely low among all three lakes (Figure 11). TPN and nitrate values were highest in Gyrfalcon Lake; however, similar to phosphorus, nitrogen values for these lakes was low. These lakes were selected for long-term monitoring because of their remote and high elevation setting and their vulnerability to change in atmospheric inputs. These lakes were also part of a "bench mark" study of Glacier Park lakes in the mid 1980s. The results of the current monitoring suggest that these lakes have not changed significantly from the earlier study.

Future Headwaters Monitoring

This initial headwater monitoring effort pointed out several potential problems areas that will help direct future monitoring and research efforts. The strength of the analysis is someshat limited because of the few sample sites. Also, major watershed disturbances such as wildfire, may also significantly affect sediment and nutrient loads. Nonetheless, we observed measureable increases in TSS and TP loading in watersheds that have had roads built and timber harvested from them relatice to unroaded watersheds in the dataset. Evidence for this is most substantive in Coal, Challenge and Lion creeks. Although this monitoring effort not differentiate between wildfire effects and timber management effects in Hand Creek, future short-term monitoring efforts should be specifically designed to evaluate post-fire management treatments, such as salvage logging.

We recommend that future monitoring efforts emphasize more measurements per stream to increase the strength of the analysis. We also recommend that an array of management prescirptions be examined, as in this analysis, with close attention to selection of streams with comparable size and geology. Finally, to minimize costs we recommend that analysis be focused on Total Suspended Solids (TSS), Total Phosphorus (TP), Soluble Reactive Phosphorus, and Nitrate.

Figure Legends

Figure 1. Selected important attributes of the monitored headwater catchments. Harvest includes all harvest activities (e.g., salvage, clearcut) combined. Data from the Flathead National Forest, US Forest Service.

Figure 2. Map of the Coal Creek watershed showing catchment boundaries, roads and harvest units by decade. Color change on the map delineates the upper watersheds of the North Fork of Coal Creek and the South Fork of Coal Creek and the mainstem of Coal Creek between the confluence of the two forks and Deadhorse Bridge, the site identified as Lower Coal Creek.

Figure 3. Map of the Lion Creek watershed showing catchment boundaries, roads and harvest units by decade. Color change on the map delineates the transition from the upper to the lower watershed.

Figure 4. Regression of instantaneous discharge in the North Fork of the Flathead River (data from USGS, Reston VA) and point measurements of discharge at the Lower Coal Creek monitoring site. This regression equation was used to estimate daily discharge throughout the year. (The same procedure was used to estimate annual water yield at all the monitoring sites) .

Figure 5. Relationship of estimated discharge and total suspended solids (TSS) in Lower Coal Creek over the three year monitoring effort.

Figure 6. Relationship of estimated discharge and soluble reactive phosphorus (SRP) in Lower Coal Creek over the three year monitoring effort.

Figure 7. Relationship of estimated discharge and nitrate (NO_3) in Lower Coal Creek over the three year monitoring effort.

Figure 8. Water yield (acre-ft), total suspended solids load (kg/acre/yr) and total phosphorus load (g/acre/yr) at each of the monitored sites during 1994 and 1995. Percentages given in Water Yield panel indicate percent of watershed harvested.

Figure 9. Total suspended solids load (kg/acre/yr), total phosphorus load (g/acre/yr), soluble reactive phosphorus load (g/acre/yr), and nitrate load (g/acre/yr x10) at Upper and Lower Hand Creek monitoring sites during 1994 and 1995.

Figure 10. Discharge (cfs), total suspended solids (mg/L), total phosphorus (mg/L) and soluble reactive phosphorus (mg/L) concentrations in the North and Middle forks of the Flathead River during 1995.

Figure 11. Phosphorus (TP and SRP) and nitrogen (TPN and nitrate) concentrations in the three alpine lakes in Glacier National Park.

Water Quality in Headwater Streams (State Forests)

The Montana Department of Natural Resources and Conservation, Trust Land Management Division, (formerly Department of State Lands) began monitoring water quality at selected sites on the Stillwater State Forest near Olney, Montana, in 1976 (Table 1). Sampling locations are in both the Whitefish Lake and Stillwater River basins. The objective of the monitoring program is to detect trends in discharge, nutrients, and sediments, to identify relationships between management activities and water quality, and to establish baseline values for comparison over time.

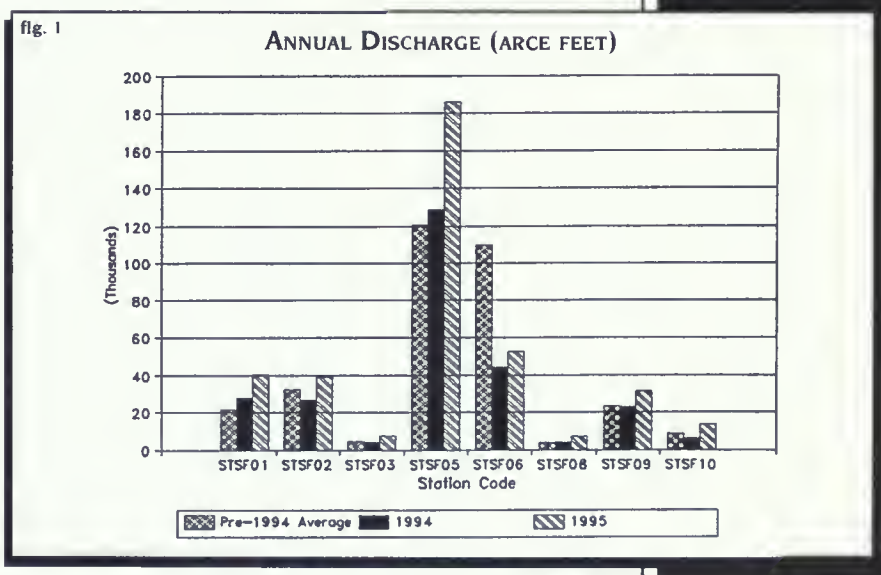
Table 1. Period of Record for Water Quality Monitoring Stations on the Stillwater State Forest

STATION NAME	STATION CODE	PERIOD OF RECORD
East Fork Swift Creek	STSF01	1976-PRESENT
West Fork Swift Creek	STSF02	1976-PRESENT
Chicken Creek	STSF03	1976-PRESENT
Middle Swift Creek	STSF05	1981-PRESENT
Lower Swift Creek	STSF06	1976-PRESENT
Chepat Creek	STSF08	1976-PRESENT
Lower Fitzsimmons Creek	STSF09	1976-PRESENT
Lazy Creek	STSF10	1985-PRESENT
Upper Fitzsimmons Creek	STSF11	1995-PRESENT

Chepat Creek and Chicken Creek are considered to be indicative of undisturbed watersheds due to the negligible amount of timber harvest and road building which has occurred in the basins. The primary landowner within the Lazy Creek drainage is Plum Creek Timber Company. The station on this stream is monitored with their financial support.

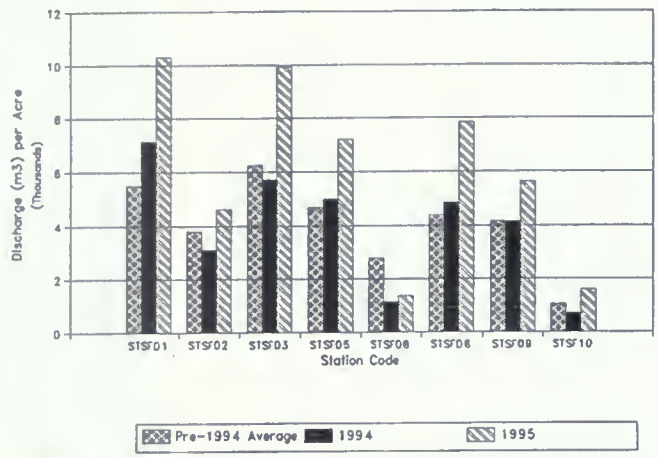
Water Yield

Increases in water yield from a given drainage may result from either greater precipitation or a reduction in water usage by vegetation as a result of timber harvest or fire. Precipitation levels in the Flathead Valley were generally below normal in 1994 and above normal in 1995. This trend is reflected in the discharge figures depicted in Figure 1. With the exception of the Lower Swift Creek site (STSF06), all locations showed water yield levels in 1995 to be above the pre-1994 values. The trend in water yield for 1994 varied considerably between the sampling sites. Three sites showed levels above average while the other five sites were below average.



Assuming that the drainages in the Stillwater have similar geology, water yield per unit area should be relatively constant for areas with similar snow accumulation and melt regimes. Water yield per acre figures are shown in Figure 2. The general trend shown is that the water yield in 1994 was near or below the pre-1994 average, while water yield in

fig. 2



1995 was much higher than the pre-1994 average for all stations except lower Swift Creek. The fact that this trend is seen consistently at all stations including Chicken and Chepat Creeks, which are essentially unroaded and without timber harvest, is evidence that the cause of this water yield increase is natural. The lower elevation watersheds show a lower magnitude increase which indicates that the cause may be associated with increases in snowpack.

Sediments

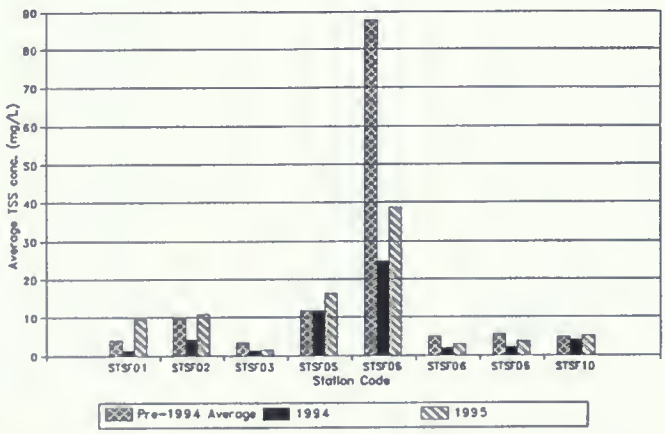
Streams naturally carry a certain sediment load. This load is determined to a large extent by the type of soil which the stream flows through, the nature and extent of the streamside vegetation, and the amount of flow in the stream. Changes in any of these factors will change the amount of sediment available to the stream. Hydrologists look for variation in suspended sediment concentration over time to indicate changes in water quality. Phosphorus has been shown to be associated with sediment so, by monitoring the sediment levels, we may also be able to draw conclusions about the nutrient loading to downstream waterbodies. In addition to carrying nutrients, fine sediment in large amounts can have a detrimental effect have on the spawning cycle of fish.

Average sediment concentrations for each annual sample period are shown in Figure 3. For all sites the 1994 values were below average. In 1995 the values for East Fork Swift, West Fork Swift, Middle Swift, and Lazy Creek were all above average. With the exception of East Fork Swift, the observed increase for each of these four sites was well within the statistical range of variation seen within the period of record. The large percentage increase seen at East Fork Swift is difficult to explain. There has been no management activity in the drainage above the sampling site in the last several years. The exceptionally large sediment concentrations observed at the Lower Swift Creek station are a result of mass wasting banks which occur naturally in the lower reaches of Swift Creek. The average sediment concentrations passing the Lower Swift Creek station (just above Whitefish Lake) in 1994 and 1995 were substantially lower than the average concentration over the previous eight years of record.

Nutrients

Studies of Whitefish and Flathead lakes have concluded that increases in nutrient concentrations will further stimulate algal productivity and should be minimized. The nutrients which are of concern in this system are phosphorus and nitrogen.

fig. 3



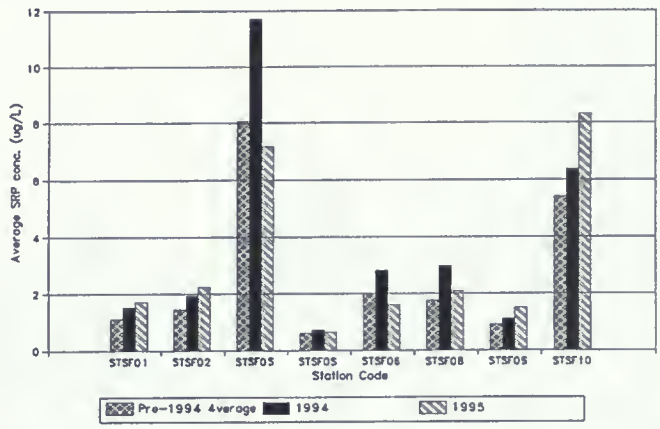
Phosphorus

It has been speculated that the primary sources of phosphate in the Stillwater River and Whitefish Lake drainages are decomposed organic matter and phosphorus compounds stored on sediments. Numerous previous studies have shown a high correlation between phosphorus concentrations and both sediment concentration and stream discharge.

One of the primary objectives of the water quality monitoring on the Stillwater State Forest is to attempt to understand the relationship between forest management activities and phospho-

rus concentrations being delivered to downstream waterbodies. To date this relationship continues to be poorly understood. Figure 4 shows the figures for average soluble reactive phosphorus (SRP) concentrations. There appears, from this data, to be poor correlation between forest management and SRP concentrations. For example, Chicken Creek (STSF03), which has had very little timber harvest and road building activity, shows relatively high SRP concentrations. The figures are higher, in fact, than those for Lower Fitzsimmons where recent timber harvest and road construction have taken place.

fig. 4



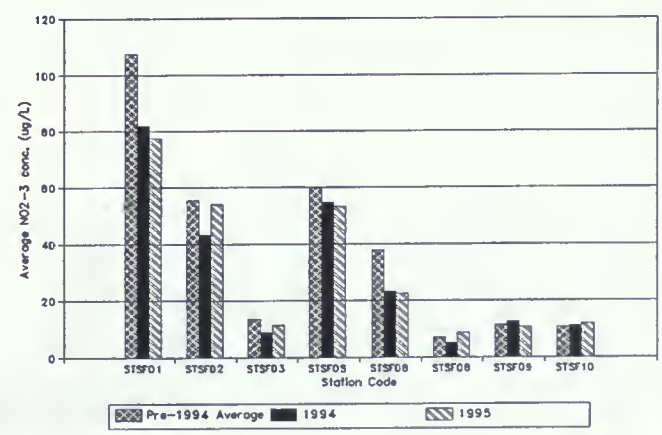
The EPA recognizes that numerical water quality standards for phosphorus must be developed on a site specific basis. A standard which is often given as the acceptable concentration for surface water which delivers to a lake is 50 parts per billion (ppb) of total phosphorus. This concentration was exceeded on five sample dates in the 1994-1995 seasons. All of the exceedance dates were in the spring and early summer, during high flow. Throughout the period of record, there have been numerous exceedances of the 50 ppb standard. These have occurred at all sampling locations, including the locations in effectively undisturbed basins. These facts indicate that the 50 ppb standard for total phosphorus may not be appropriate for streams in the Stillwater State Forest.

Nitrogen

Another nutrient which may contribute to problematic algal productivity is nitrogen, specifically in the form of nitrate (NO_3). Figure 5 shows an unexpected pattern of nitrate concentration. There seems to be little correlation between nitrate concentrations and forest management activities or drainage area. With the exception of Chicken Creek, the watersheds in the Swift Creek drainage (STSF01 - STSF06) had nitrate concentrations greater that watersheds in the Stillwater River drainage (STSF08- STSF10) by approximately an order of magnitude. This would seem to indicate that there is some natural source of higher concentrations of nitrate in Swift Creek or some inherent buffering capacity of the land in the Stillwater drainage.

One sample in the spring of 1993 exceeded 0.30 parts per million level, which is recommended by the Department of Environmental Quality as a reasonable standard for nitrate. All other samples in every year have been below this level.

fig. 5



Fisheries

Fisheries in the Flathead Basin continue to be of major concern. The Flathead is one of a very few areas in the country still supporting self-sustaining populations of native westslope cutthroat and bull trout. These species are particularly sensitive to environmental disturbance and are used as indicators of aquatic habitat quality. Monitoring has shown declines in abundance in parts of the basin during recent years. This monitoring includes counting the number of redds (individual spawning nests) and tracking juvenile fish abundance as well as indexing both spawning and rearing habitat quality at specific sites basin-wide. Information from these monitoring activities is being used to evaluate regulations and formulate recommendations for management actions.

Bull Trout

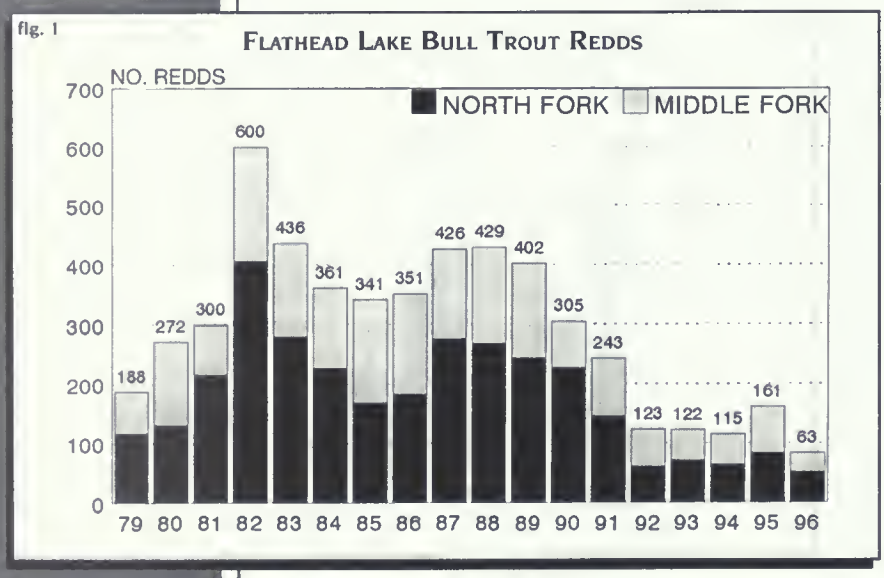
Bull trout are a glacial relict species. They have extremely strict habitat requirements. The fact that they are still present here illustrates that water quality is good and suitable habitat is present. Because bull trout are good indicators of aquatic ecosystem health, the Flathead Basin Commission's Master Monitoring Program calls for a program to track bull trout population and habitat status basin-wide. This ongoing program now provides the most extensive bull trout data set available.

Historically, bull trout utilized the entire interconnected Flathead River watershed including its North, Middle, and South forks as well as the Swan, Whitefish, and Stillwater rivers. Due to construction of Bigfork Dam in 1902 and Hungry Horse Dam in 1953, bull trout in the Swan and South Fork Flathead drainages are now isolated from the main Flathead population. All three of these populations are dominated by a migratory life history. The adult fish reside in lakes but travel upstream to tributary drainages where they spawn. After hatching, juvenile fish grow from one to three years in natal streams before migrating downstream to lakes where they mature at age six.

Flathead Lake Population

During the past 18 years, Montana Fish, Wildlife & Parks (FWP) has monitored known spawning areas in tributaries to the North and Middle forks of the Flathead River (Figure 1). Fish that use these streams spend their adult lives in Flathead Lake. After some initial fluctuation, redd numbers in the eight index areas stabilized throughout the 1980s. A declining trend began in 1990, reaching a very low but relatively stable level from 1992 through 1995. The 1996 count of 83 redds in our eight Flathead Lake index streams is the lowest on record to date and is cause for concern over the future viability of this population. Only one stream had more than ten redds during 1996.

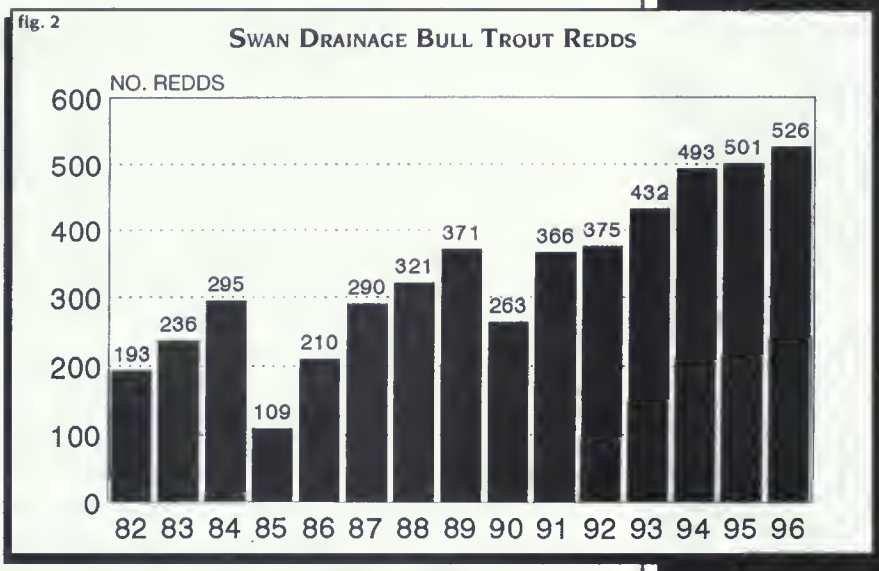
fig. 1



Monitoring of spawning and rearing habitat quality over this same time period has shown that fine sediment levels increased throughout the drought period during the 1980s. The highest sediment levels occurred in 1988, 1989, and 1990, but flushing flows since 1991 have improved conditions to levels similar to the early 1980s. Currently, our monitoring shows spawning and rearing habitat quality is generally in good condition.

Juvenile bull trout abundance in Flathead tributaries has also declined during recent years. In the early 1990s we began to

see extremely weak year classes. Biologists now believe that nursery habitat is not being adequately seeded due to low levels of spawning since 1992. It appears that low redd numbers resulted from years where juvenile densities were still relatively high, suggesting that survival of the out-migrants in the river or lake was poor. Recent changes in the ecological balance of Flathead Lake are now believed to be impacting this bull trout population. These changes occurred after the establishment of *Mysis* shrimp. *Mysis* densities peaked in 1986, resulting in enhanced survival and growth of lake trout and lake whitefish. Numbers of these two species peaked in 1989 and 1990 and observations of them in the river became more frequent. It is now likely that a combination of competition for food and space between juvenile bull trout and these two species and predation by lake trout are responsible for the decline in bull trout abundance in Flathead Lake.

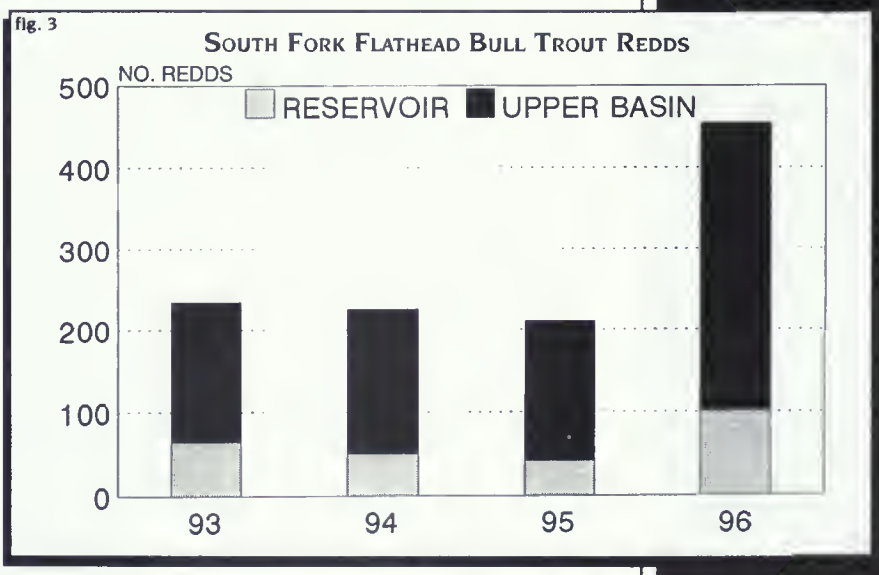


Swan Lake Population

During the past 15 years, FWP (in cooperation with Flathead National Forest) has monitored known spawning areas in tributaries to the Swan River (Figure 2). Fish using these streams spend their adult lives in Swan Lake. This population appears to be stable or increasing over the period of record. The four annual index areas contain approximately 70 percent of all bull trout spawning in the drainage. Biologists believe the increasing trend is due to more restrictive angling regulations in recent years. Currently, the entire river and its tributary network are closed to fishing for bull trout. Swan Lake is the only water in the state where bull trout harvest is still allowed with a daily limit of one fish.

A second factor which may be contributing to the observed trend is the increase in the food supply for juvenile and sub-adult fish in Swan Lake which resulted from establishment of *Mysis* shrimp. *Mysis* in Swan Lake are not a negative factor as in Flathead Lake because of the absence of lake trout and lake whitefish.

Spawning and rearing habitat quality are also monitored by FWP and currently conditions are good. Juvenile bull trout abundance estimates show healthy populations in the index streams. Although this population appears stable or increasing at present, serious threats still exist. The greatest risk is from an illegal introduction of lake trout which are present in high numbers immediately downstream from Bigfork Dam. Introduced species currently present include brook trout, northern pike, and yellow perch which create a threat. Forestry and rural residential development are also considered risks to this population.



South Fork/Hungry Horse Reservoir Population

Redd counts were conducted in South Fork tributaries for the first time during 1993, so long-term comparisons are not possible (Figure 3). Our monitoring counts are for four reservoir and four wilderness streams. Trend data from gillnetting in the reservoir since 1958 suggest relative stability. Because Hungry Horse Reservoir and the river upstream maintains a native species assem-

blage and is largely not threatened by introduced species, it has become a critical refuge for bull trout and westslope cutthroat trout.

However, the reservoir has been subject to extreme water level fluctuations as witnessed by the record 188-foot drawdown in April 1993. There are major concerns about the impact of deep drawdowns on native trout populations. Deep drawdowns have occurred with increasing regularity in recent years due to drought, changing operations, and power demands and the need for water downstream to provide salmon flows. The 1996 spawners were the only ones monitored to date which were not subject to deep drawdown while in the reservoir. The 1996 count was more than double any of the three preceding years. Recent angling restrictions may also have contributed to the high count in 1996.

Major portions of the bull trout spawning and rearing habitat in the South Fork are protected by wilderness designation. Spawning and rearing habitat quality is presently in good condition. Logging around the reservoir and in the Spotted Bear River and Bunker Creek drainages creates some risk. The threat of an illegal fish introduction also exists.

Disjunct Populations

Due to the overall lack of information regarding regional bull trout populations other than the three previously discussed, FWP has begun tracking several smaller, isolated populations. These data sets are not long enough to assess trends but they do provide some indication of relative abundance. Monitoring occurs on the following lake systems: Whitefish, Upper Whitefish, Upper Stillwater, Cyclone, Holland, Lindbergh, Big Salmon, Tally, and Frozen. There are approximately 20 additional lakes supporting bull trout where little information is available. The majority of these are located in Glacier National Park.

ESA Petition

A petition to list bull trout under the Endangered Species Act was filed by several Flathead area resource groups in October 1992. Upon completion of the 90-day review, the United States Fish and Wildlife Service (FWS) found the petition to have merit and initiated a full, one-year status review in May 1993. At the end of this period, the Service's finding was that based on existing data, bull trout listing was warranted but precluded (June 1994). A priority ranking of nine was assigned, which meant that bull trout faced a "moderate" magnitude of threat. In January 1995, FWS upgraded the priority ranking from nine to three, indicating a "high" magnitude of threat. On June 12, 1995, FWS issued its 12 month petition finding, again concluding listing was warranted but precluded with a priority ranking of nine. On November 13, 1996, United States District Judge Robert E. Jones issued an opinion that the 1994 finding was arbitrary and capricious and remanded the case to the FWS for reevaluation. The FWS was given until March 1997 to complete its reevaluation.

Forestry Practices Update

Best Management Practices (BMPs) are voluntary guidelines that establish minimum accepted standards for timber harvesting, road building, and other forest operations activities. The objective of BMPs is to protect water quality.

Since their formalization through legislative action in 1989, BMPs have helped those involved in timber management improve the application and effectiveness of their management practices.

The 1996 audit concludes that the greatest departures from BMPs were associated with road drainage. The audit documented improvement over the 1994 audit in seven of eight evaluation criteria, but it pointed out that 34 percent of sites experienced major departures in BMP effectiveness and 29 Streamside Management Zone (SMZ) infractions were noted.

The effect of forestry practices on the aquatic environment can be further minimized through adherence to Montana's SMZ law, which went into effect in 1993. The law applies to water courses that meet the definition of a stream, lake or Other Bodies of Water (OBW) in instances where forestry practices meet the definition of a timer sale.

For comprehensive information relating to the effect of forestry practices on water quality and fisheries in the Flathead Basin and criteria developed to protect those resources, please refer to "Flathead Basin Forest Practices Water Quality and Fisheries Cooperative Program Final Report," available from the Flathead Basin Commission. The report summarizes 10 individual studies conducted in the Basin relating to the historical perspective, water quality and fisheries, evaluation of forest practices, and evaluation of watersheds.

Forestry BMP Audits	**1990**	**1992**	**1994**	**1996**
Industrial Private Lands	78	91	95	94
Non-Industrial Private	61	70	88	86
State Lands	81	97	92	96
Federal Lands	86	88	88	93
Statewide Average	78	87	91	92

Conclusions

This report has not attempted to thoroughly interpret all the data in the water quality monitoring database. Rather, the researchers involved have identified and analyzed key findings. This progress report pertains to the overall objective of monitoring water quality in the Flathead Basin as detailed in the discussion of the Monitoring Master Program on page12 of the Biennial Report.

Much of the water in the Flathead Basin drains out of National Park land and wilderness areas and, in general, waters in the Basin continue to rank among the finest in temperate regions of the world. Some lakes in Glacier National Park have the cleanest water documented in scientific literature, and the water quality of Flathead Lake is ranked in the top 10 percent for lakes of its size in the temperate latitudes of the world.

To protect this high quality aquatic system, a variety of monitoring procedures must be continually applied to various water quality variables, and resource managers should be encouraged to use these data in making management decisions.

Although Flathead Basin waters are generally considered to be very clean, trends that identify a deterioration of water quality and a decline in important native fisheries are of concern. The following conclusions highlight aspects of ongoing studies that are being carried out in compliance with the Flathead Basin Commission Master Monitoring Program.

A. Ongoing research at the Ross Deep site continues to document reduced dissolved oxygen levels in the bottom layers at the site. Such deterioration of water quality is of significance because hypolimnetic oxygen reduction is an indication of cultural eutrophication, a phenomenon linked to enrichment from nutrient pollution.

B. Because of the high quality waters in the Flathead Basin, aquatic plants and animals have naturally low productivity rates. Increases in productivity rates indicate declines in water quality. Therefore, the lake-wide trend of increasing primary production of phytoplankton (the propensity of the lake to grow algae) is of concern. The trend suggests that algae and other microorganisms in the lake are being fertilized by excess nutrients from the drainage Basin and from polluted precipitation that falls on bodies of water throughout the Basin.

C. Pollution of Ashley Creek by the Kalispell Waste Water Treatment Plant has significantly abated as a result of the installation of new treatment technology and the existence of a ban on the sale of consumer cleaning products containing phosphorus. However, the sediments of Ashley Creek contain a great deal of phosphorus and nitrogen. Hence, sediment release may somewhat offset improvements in water quality attributable to better sewage treatment, at least for several years.

D. Phosphorus from the urban sewage plants has declined more than 15 percent since 1988 as a result of the implementation of the phosphorus reduction plan of the Montana Water Quality Division. Reduced discharge of P and N from the waste treatment facilities in the Flathead Basin, a positive development, may be responsible, at least in part, for stabilization of annual primary productivity in recent years.

E. There is natural variation in nutrients, sediment loads and flow coming from the headwater streams in the Flathead Basin. This natural variation between watersheds makes interpretation of monitoring results difficult.

F. Watersheds can experience significant increases in nutrients following wildfires. Even small prescribed fires can result in measurable increases in nutrients.

G. Although equivocal, it appears that generally watersheds with the highest loadings of nutrients and sediment were associated with watersheds that have had land management activities.

H. The sampling design employed during the 1994 through 1996 monitoring period was not sufficient to determine if the present level of BMP application is successful in protecting aquatic habitats.

I. The inter-connected Flathead Basin historically supported what is probably the largest migratory bull trout assemblage in the world. Population segments have seriously declined in Flathead Lake and the North and Middle forks of the Flathead River. Bull trout populations in the Swan and South Fork Flathead drainages, however, are presently healthy.

J. Recent bull trout declines in all Flathead monitoring areas indicate changes in Flathead Lake and/or main stem Flathead River are a major threat. Establishment of *Mysis* and proliferation of lake trout and lake whitefish play a key role, but actual mechanisms are not presently understood. It is uncertain whether recovery is possible.

K. The Swan Drainage currently supports the most abundant bull trout assemblage in Montana. The greatest threats stem from future illegal fish introductions and the introduced fish already established in the drainage. The potential for degraded habitat conditions resulting from forestry and rural residential development is also of concern. Other risks stem from angling and illegal harvest.

L. The South Fork Flathead Drainage above Hungry Horse Dam constitutes the most intact fish ecosystem in western Montana. A large portion of the area is in wilderness and is inhabited by native species. An illegal fish introduction represents the greatest threat, followed by extreme water level manipulations in the reservoir, forest management activities, and illegal harvest.

M. The Flathead River System supports some of the most important known populations of genetically pure westslope cutthroat trout. These fish are valuable, unique, and a vital part of the ecological integrity and quality of life in the Basin.

N. Monitoring of spawning/incubation and juvenile rearing habitat quality indicates that sediment levels peaked Basin-wide between 1988 and 1990. Since the spring of 1991, flushing flows have reduced the amount of deposited fine sediment, and habitat quality in the nursery tributaries is presently good.

O. Ongoing monitoring in the Stillwater State Forest suggests that, except for isolated occurrences at Lower Swift Creek, the waters in the Forest appear to be highly suitable for recreational, domestic, fisheries, and irrigation uses. The seasonal flush of high Total Suspended Sediments (TSS) appears to be associated with natural erosion of glacial outwash deposits.

P. The Flathead Basin Commission's Volunteer Monitor Program provides data from 30 lakes in the Basin that is of value as a supplement to data gathered through agency, academic, and corporate monitoring efforts. Volunteer monitor data suggests that water quality in these lakes is quite variable and illustrates the importance of this data to management.

Q. Land owners and managers are increasingly applying Best Management Practices and observing the guidelines of the Streamside Management Zone law. The 1996 Best Management Practices audits indicate continued improvement in seven out of eight criteria used to evaluate the application and effectiveness of BMPs.

Recommendations

The preservation of the quality of life associated with the Flathead Basin and the maintenance of a sustainable economy depend on protecting the current high level of water quality present in the Basin. Therefore, the future of the Flathead Basin depends on how well decision-makers understand the damaging effects of certain kinds of human activities and whether they heed the warning signs and adjust management practices accordingly.

The Flathead Basin Commission should encourage all relevant entities, including both member organizations of the Commission and others present in the Basin, to work cooperatively to respond to the recommendations of this report.

1. Participants in the Monitoring Master Program are experiencing greater difficulty in maintaining their funding. Appropriate entities, including the Montana Legislature, the U.S. Congress, U.S. EPA, and other state, local, corporate, and public interest organizations should be encouraged to assist the Commission in attaining its monitoring objectives by contributing to the funding of the Monitoring Master Program.

2. The long-term water quality monitoring program for Flathead Lake should be continued in order to document any changes in the lake's status and to facilitate the ongoing Total Maximum Daily Load (TMDL) effort.

3. Research should be funded to determine the cause of the hypolimnetic oxygen deficit in Big Arm Bay at the Ross Deep site. Shoreline sources of pollution and pollution from Dayton Creek and the possibility of entrainment of river water in the bay are possible explanations that should be investigated thoroughly. Knowledge of the rate of reduction of oxygen levels at deep lake sites is essential to determining long term trends and understanding the relationship between oxygen reduction and nutrient loading from all sources.

4. The nutrient reduction and TMDL strategy of the Department of Environmental Quality should continue to guide management actions in the Flathead Basin to reduce nutrient pollution. Greater attention should be paid to documentation and reduction of nonpoint sources, especially with respect to increasing fertility of the Stillwater and Whitefish rivers, Ashley, Blaine and Mill creeks, and the Evergreen alluvial aquifer as they flow through the Flathead Valley and discharge into the Flathead River. Additional water quality monitoring sites are needed to determine how land use activities are associated with nonpoint source inputs into these water bodies. Predictive knowledge of sewage leachates from septic systems and soil capacities for new systems is badly needed in view of the rapid growth of homes and businesses outside of the sewer districts in the Basin.

5. Efforts by the Flathead Basin Commission to develop a water quality management program for the Flathead Basin should be responsive to the conclusions and recommendations of the TMDL study. Control of nonpoint sources of nitrogen and phosphorus and the implementation and monitoring of Best Management Practices should be emphasized in all planning processes.

6. The Flathead Basin Commission should encourage the development and application of Best Management Practices for all land use activities in the Basin. The primary goal should be to conduct activities in such a manner so as to minimize sediment and nutrient inputs to all Basin surface and ground waters. Use of development setbacks, buffer strips, limitations on fertilizer uses, and animal waste and road runoff management systems should be emphasized.

7. Future short-term monitoring efforts should be designed to separate effects of different land management activities, and more specifically address the question of whether Best Management Practices are protecting aquatic environments.

8. To maximize the strength of analysis, the current array of sampling parameters, sampling frequency, and sampling locations should be reviewed and adjusted. Future monitoring should be developed with a paired watershed design.

9. The Flathead Basin Commission should encourage efforts to develop criteria related to the allowable amount of deposited sediment, percentage of fine sediment, substrate scores, bedload, suspended sediment in critical bull trout and westslope cutthroat trout streams, and relationship to the application of Best Management Practices (BMPs).

10. Although the long term trend of BMP audits reflects overall and ongoing improvements in most forest management practices, the Flathead Basin Commission should encourage timber resource managers to take further steps to improve their BMP scores and insist that regulatory agencies take necessary steps to address serious violations. Of specific concern are findings in the 1996 BMP Audits report that document major departures in BMP effectiveness at 34 percent of audited sites, an increase of six percent over 1994, and 29 SMZ law infractions. The Commission should also encourage a reduction of activity and additional caution in SMZs in drainages supporting populations of bull trout and cutthroat.

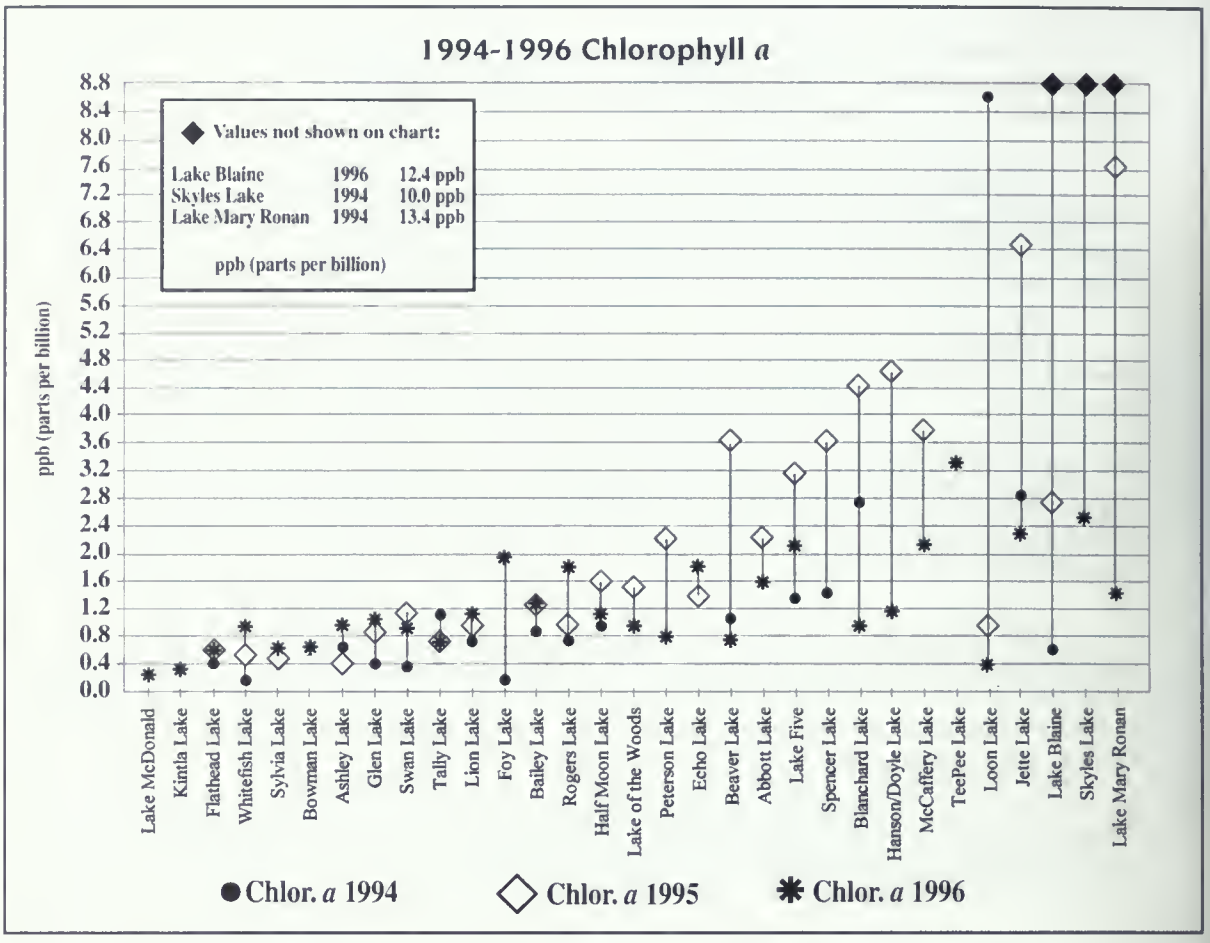
11. The Flathead Basin Commission should intensify its efforts to inform individuals and organizations about how they can protect water quality in the Flathead Basin. The ongoing process should include efforts to inform the public and private sector leadership and the general public of key findings so all can be involved in assisting in the development of strategies for limiting new and reducing existing pollution sources.

12. The Commission should encourage individuals and organizations to actively participate in monitoring activities through the Volunteer Monitor Program and other activities which contribute to the overall water quality monitoring and protection effort.

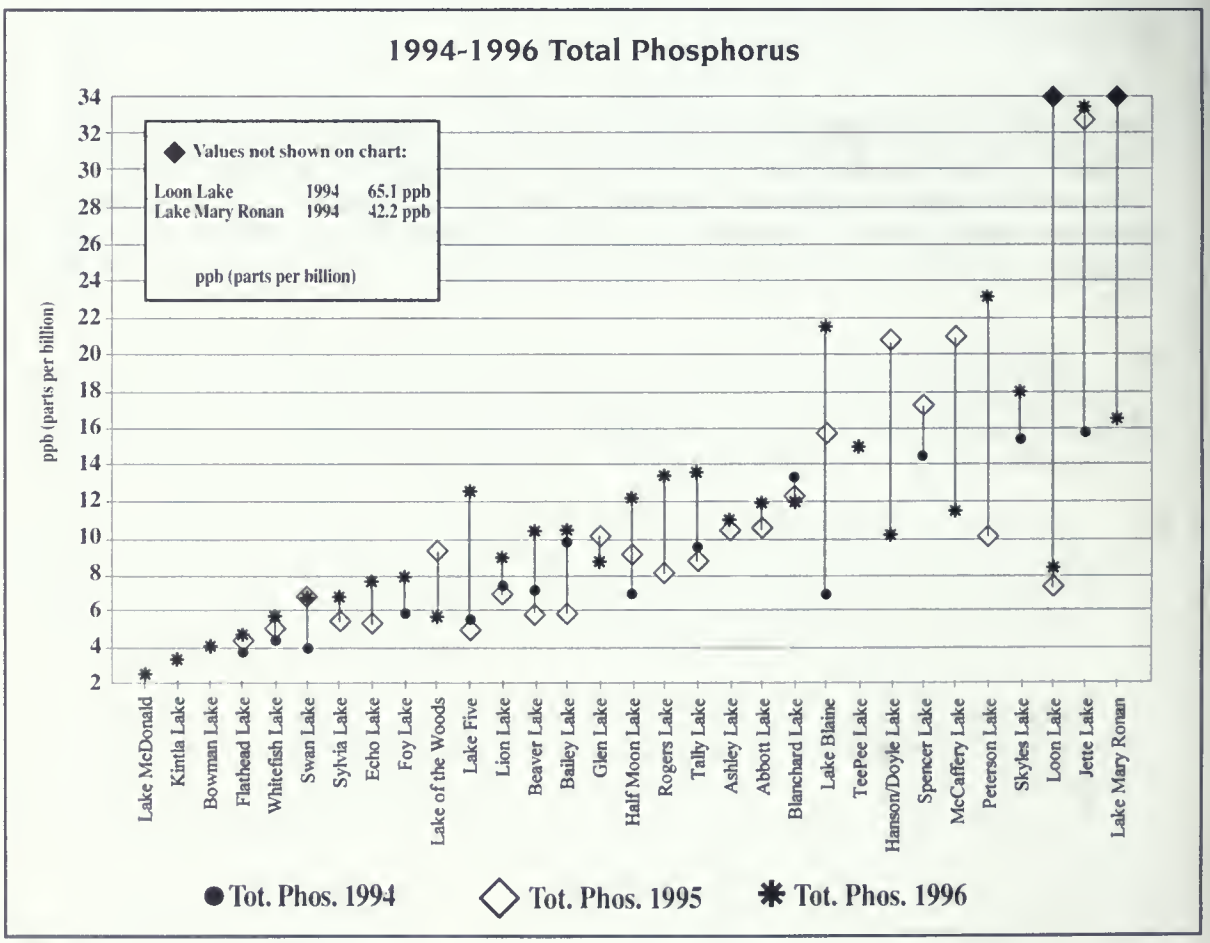
13. The Commission should encourage efforts to determine bull trout population status in the disjunct lakes in the Basin. These lakes are listed on page 18 of the Status Review for Flathead Lake prepared by the Montana Bull Trout Scientific Group.

The efforts of the Commission's Monitoring Committee are critical to the monitoring, protection, and preservation of the Basin's relatively clean and healthy aquatic environment. Other public and private agencies and organizations and individuals should cooperate and participate to the greatest extent possible to assist the Monitoring Committee in achieving its goals.

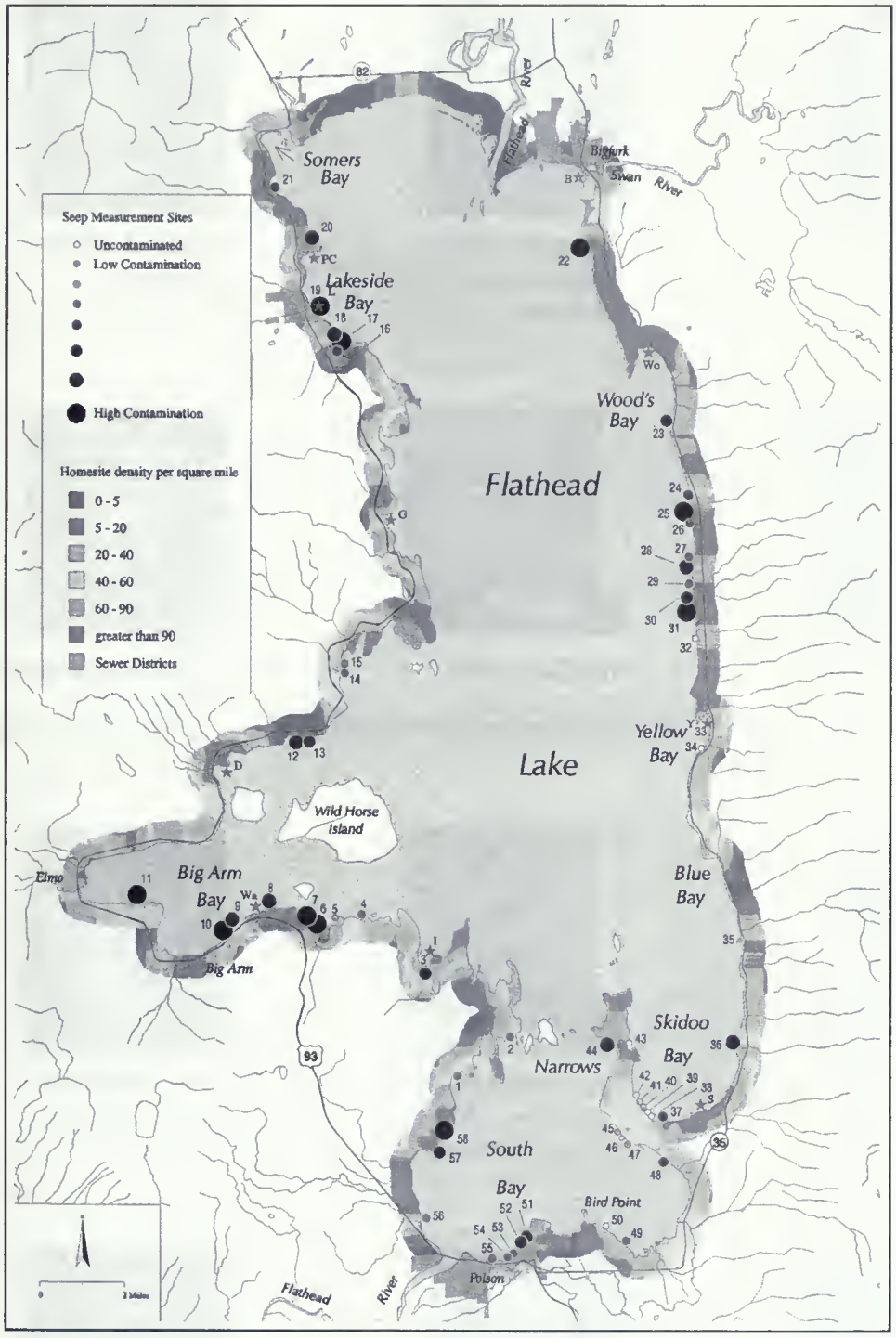
Chlorophyll a is the green molecule in plant cells that carries out photosynthesis. It is used as an indicator of plant and algae productivity and acts as an empirical link between nutrient concentrations and other biological phenomena in lakes. Higher values suggest deteriorating water quality.



Total Phosphorus is the sum of all forms of phosphorus. In excessive amounts in lakes and streams, phosphorus can lead to over fertile (eutrophic) conditions and algae blooms. The higher the reading, the more serious the water quality problem.



For more information on water quality in Flathead Basin lakes, request a copy of the "Volunteer Monitor Program 1992-1995 Comprehensive Report," available at the Commission office.



Produced by
Natrual Resources Department GIS
Confederated Salish and Kootenai Tribes
of the Flathead Nation

Shoreline development poses direct threats to existing water quality. This study of population density on Flathead Lake, conducted by the Confederated Salish and Kootenai Tribes, provides needed information about growth patterns on the lake.

Members of the Flathead Basin Commission

Elna Darrow
Chair
Citizen Member
Bigfork

Art Vail
Citizen Member
Whitefish

Marilyn Wood
Citizen Member
Bigfork

David Mihalic
Superintendent
Glacier National Park
West Glacier

William Gregg
Citizen Member
Polson

Rodd Richardson
Supervisor
Flathead National Forest
Kalispell

Rhonda Swaney
Council Chair
Confederated Salish &
Kootenai Tribes
Pablo

Dr. Paul Smiley
Citizen Member
Columbia Falls

Larry Wilson
Citizen Member
Columbia Falls

Jon Dahlberg
Area Manager
MDNRC Northwest
Lands Office
Kalispell

Forrest Sanderson
Land Services Department
Lake County
Polson

Dale Williams
County Commissioner
Flathead County
Kalispell

Steven Foster
Ex-officio Member
U.S. Army Corps of Engineers
Seattle

Dan Vincent
Ex-officio Member
Regional Supervisor
MDFWP
Kalispell

Van Jamison
Ex-officio Member
MDHES Water Quality Division
Helena

Gail Kuntz
Ex-officio Member
Bonneville Power Administration
Helena

Dennis McDonald
British Columbia Liaison
Regional Supervisor
B.C. Environment
Nelson

Robert O'Leary
Ex-officio Member
Montana Power Company
Butte

Rich Moy
Ex-officio Member
Water Management Bureau
MDNRC
Helena

Ralph Carter
Ex-officio Member
Superintendent
U.S. Bureau of Reclamation
Hungry Horse Project
Hungry Horse

William Engle
Ex-officio Member
U.S. Environmental Protection Agency
Helena

Mark Holston
Public Information Officer
Kalispell

Flathead Basin Commission Establishing Legislation

75-7-301. Short title. This part may be cited as the "Flathead Basin Commission Act of 1983".

History: En. Sec. 1, Ch. 424, L., 1983.

75-7-302. Purpose. The purpose of the Flathead basin is to protect the existing high quality of the Flathead Lake aquatic environment; the waters that flow into, out of, or are tributary to the lake; and the natural resources and environment of the Flathead basin.

History: En. Sec. 2, Ch. 424, L. 1983.

75-7-303. Definitions. As used in this part, the following definitions apply:

(1) "Aquatic resources" means all beneficial uses of water, including but not limited to water quality and water supply; recreational, scenic, and aesthetic values; and fish, wildlife and other organisms.

(2) "Commission" means the Flathead basin commission established in 2-15-213.

(3) "Flathead basin" means all land and water areas the water from which drains into Flathead Lake or its tributaries.

History: En. Sec. 3, Ch. 424, L. 1983.

75-7-304. Duties of the commission. Duties of the commission are:

(1) to monitor the existing condition of the natural resources in the basin and coordinate development of an annual monitoring plan. This plan must involve a cooperative strategy among all land and water management agencies within the Flathead basin and identify proposed and needed monitoring which emphasizes but is not limited to the aquatic resources of the Flathead basin.

(2) to encourage close cooperation and coordination between federal, state, provincial, tribal, and local resource managers for establishment of compatible resource development standards, comprehensive monitoring, and data collection and interpretation;

(3) to encourage and work for international cooperation and coordination between the state of Montana and the Province of British Columbia concerning the undertaking of natural resource monitoring and use of consistent standards for management of resource devel opment activities throughout the North Fork Flathead River drainage portion of the Flathead basin;

(4) to encourage economic development and use of the basin's resources to their fullest extent without compromising the present high quality of the Flathead basin's aquatic environment;

(5) to, in the discretion of the commission, undertake investigations of resource utilization and hold public hearings concerning the condition of Flathead Lake and Flathead basin;

(6) to submit a biennial report to the governor and the appropriate committees of the legislature that includes:

(a) a summary of information gathered in fulfillment of its duties under this section;

(b) information on monitoring activities within the Flathead basin concerning the condition of the basin's natural resources, with particular emphasis on Flathead Lake;

(c) the identification of land use and land development trends in the Flathead basin;

(d) any recommendations the commission considers appropriate for fulfillment of its duties and for continued preservation of the Flathead basin in the present high quality of its aquatic resources; and

(e) an accounting of all money received and expended, by source and purpose, for the period since the last report; and

(7) to meet at least semiannually within the Flathead basin, alternating the meeting site between the cities of Kalispell and Polson.

History: En. Sec. 7, Ch. 424, L. 1983.

75-7-305. Commission authority.

(1) The commission may make recommendations to the legislature and the governor and to federal, tribal, provincial, and local agencies for maintenance and enhancement of the quality of natural resources of the Flathead basin.

(2) The commission may receive and expend donations, gifts, grants, and other money necessary to fulfill its duties.

History: En. Sec. 8, Ch. 424, L. 1983; amd. Sec. 1, Ch. 244 L. 1985; amd. Sec. 9, Ch. 628, L. 1989.

75-7-306. Establishment of account. There is established in the state special revenue f und a Flathead basin commission account. Money received by the Flathead basin com mission under 75-7-305 and such other funds as are designated or appropriated for its use must be deposited in the account.

History: En. Sec. 9, Ch. 424, L. 1983; amd. Sec. 48, Ch. 281, L. 1983; amd. Sec. 7, Ch. 700, L. 1989.

75-7-307. Special county government authority. The governing body of any county within or bordering upon the Flathead basin may allocate to the Flathead basin commis sion a portion of any money available from coal severance tax allocations or other sources and designated for planning activities.

History: En. Sec. 10, Ch. 424, L. 1983.

75-7-308. Cooperation with other agencies and organizations. To fulfill its duties, the commission shall develop and maintain cooperative programs with federal, state, provin cial, tribal, and local agencies or organizations that are responsible for natural resource management and monitoring in the Flathead basin. Participating federal and provincial agencies must be requested to provide adequate funds to participate on the commission and to monitor resources within their areas of responsibility.

History: En. Sec. 11, Ch. 424, L. 1983.

CHAPTER NO. 95

2-15-213. Flathead basin commission-membership-compensation.

(1) There is a Flathead basin commission.

(2) The commission consists of 21 members selected as follows:

(a) seven members appointed by the governor from industrial, environmental, and other interests affected by Title 75, chapter 7, part 3, one of whom must be on the governor's staff and who also serves as the executive director;

(b) one member who shall be the commissioner of state lands or his designee;

(c) one member appointed by the Flathead County commissioners;

(d) one member appointed by the Lake County commissioners;

(e) one member appointed by the Confederated Salish and Kootenai Tribes;

(f) one member appointed by the United States department of agriculture, forest service regional forester for the northern region;

(g) one member appointed by the United States department of interior national park service, regional director for the Rocky Mountain region;

(h) six ex-officio members appointed respectively by the chief executive of the provincial government of the Province of British Columbia, the regional adminis trator of the United States environmental protection agency, the regional admin istrator of the United States department of interior, bureau of reclamation, the administrator of the Bonneville Power Administration; the chief of engineers of the United States army corps of engineers, and the holder of a license issued for the Flathead project under the Federal Power Act;

(i) two ex-officio members who shall be the director of the department of health and environmental sciences and the director of the department of fish, wildlife and parks or their designees.

(3) The commissioners shall serve without pay. Commissioners mentioned in subsection (2)(a), except the commissioner on the governor's staff, are entitled to reimbursement for travel, meals, and lodging while engaged in commission business, as provided in 2-18-501 through 2-18-503.

(4) The commission is attached to the governor's office for administration purposes only.

History: En. Sec. 4, Ch. 424, L. 1983; amd. Sec. 1, Ch. 95, L. 1985; amd. Sec. 1, Ch. 176, L. 1989.

2-15-214. Flathead basin commission-term of appointment-quorum-vacancy-chair man-vote.

(1) The commission members shall serve staggered 4-year terms.

(2) A majority of the membership, other than ex-officio members, constitutes a quorum of the commission.

(3) A vacancy on the commission must be filled in the same manner as regular appointments, and the member so appointed shall serve for the unexpired term to which he is appointed.

(4) The commission shall select a chairman from among its members. The chairman may make motions and vote.

(5) A favorable vote of at least a majority of all members, except ex-officio members, of the commission is required to adopt any resolution, motion, or other decision of the commis sion.

History: En. Sec. 5, Ch. 424, L. 1983.

2-15-215. Flathead basin commission staff and office location.

(1) The executive director of the commission shall be compensated on a pro rata basis from commission funds, calculated upon the time he is required by the governor to serve the commission.

(2) An office for the commission may be established at a community located in the basin, and sufficient and appropriate staff must be assigned to serve the commission.

History: En. Sec. 6, Ch. 424, L. 1983.

Glossary

Acid precipitation	All forms of precipitation that have an acidity lower than normal rainfall (pH 5.6).
Acre-foot	The amount of water needed to cover one acre of surface area to the depth of one foot (12 inches).
Aggradation	The build-up of sediments at the headwaters of a lake or reservoir or at a point where streamflow slows to the point that it will drop part or all of its sediment load.
Algae	Simple one-celled or many-celled plants, capable of photosynthesis; usually aquatic.
Algal bloom	Rapid growth of algae on the surface of lakes, streams, or ponds; stimu lated by nutrient enrichment.
Alluvium	Sand, clay, and other earth materials gradually deposited by streams along river beds and floodplains.
Analysis of covariance	A statistical procedure that examines the relationship between two or more measures simultaneously (i.e., one dependent variable and one or more independent variables).
Anthropogenic	Relating to the scientific study of the origin of man; human.
Aquatic	Plants or animal life living in, growing in, or adapted to water.
Aquifer	Saturated geologic material sufficiently permeable to yield significant quantities of water to wells and springs; described as artesian (confined) or water table (unconfined).
Available nutrient	That portion of any element or compound (such as phosphorus and nitrogen) in the soil that can be readily absorbed and assimilated by growing plants.
Bank stabilization	Implementation of measures along a streambank to prevent or reduce bank erosion.
Bank storage	The water which infiltrates the banks of a stream channel during high flows or floods, is stored there, and is released to the stream after the high water recedes.
Basin	A physiographic region bounded by a drainage divide; consists of a drainage system comprised of streams and often natural or man-made lakes. (Also called drainage basin or watershed.)
Best Management Practices (BMPs)	Methods, measures, or practices to prevent or reduce water pollution.
Biochemical Oxygen Demand (B.O.D.)	The quantity of oxygen utilized in the biochemical oxidation of organic matter in a specified time and at a specified temperature. Waste discharges containing high levels of B.O.D. will deplete oxygen supplies in receiving waters.

Biological availability Refers to the form that a substance or compound can take that can be readily used for plant or animal growth. Depending on their chemical structure, certain compounds are more available for plant growth than others.

Buffer strip Strips of grass or other erosion-resistant vegetation between a waterway and an area of more intensive land use.

Chlorophyll *a* The green molecule in plant cells that carries out photosynthesis. It is used as an indicator of plant and algae productivity and acts as an empirical link between nutrient concentrations and other biological phenomena in lakes. Higher values suggest deteriorating water quality.

Cubic feet per second (cfs) A unit expressing rate of discharge, typically used in measuring streamflow. One cubic foot per second is equal to the discharge in a stream of a cross section one foot wide and one foot deep, flowing with an average velocity of one foot per second; equals 448.8 gallons per minute.

Data base A collection of information kept in accessible form for purposes of research, comparison and analysis.

Dissolved Oxygen (DO) The amount of free oxygen dissolved in water and readily available to aquatic organisms.

Easement A legal instrument enabling the giving, selling, or taking of certain land or water rights without transfer of title, such as for the passage of utility lines.

Effluent Liquid attributed to human waste, i.e. sewage arising from various uses of water; often refers to waste water from a sewage treatment or industrial plant.

Ephemeral stream A stream that flows only part time usually during snow melt periods or following rainstorms.

Erosion The removal or wearing away of soil or rock by water, wind or other forces or processes. Erosion occurs naturally from weathering or runoff, but can be intensified by land clearing practices.

Eutrophication The addition of nutrients to a body of water. Accelerated by human activities, abundant growth of aquatic plants may consume much of the dissolved oxygen, making the lake uninhabitable for the previous diversity of fish and other aquatic life.

Floodplain Any normally dry land area that is susceptible to being inundated by water from any natural source. This area is usually lowland adjacent to a stream or lake.

Fluvial deposits Sediments deposited by river action.

Fresh water Clean, unpolluted water without salinity.

Groundwater The supply of fresh water that forms a natural reservoir under the earth's surface in soil and bedrock.

Groundwater recharge	The natural renewal of ground water supplies by infiltration of rain or other precipitation through the soil.
Hydrograph	A graph showing the changes in discharge of a stream or river, or the changes in water levels of a well with the passage of time.
Hydrology	The area of science dealing with the study of the waters of the earth and its atmosphere.
Hypolimnion	The lowermost, non-circulating layer of cold water in a thermally strati fied lake; usually deficient of oxygen.
Instream flows	The water left in a stream to maintain the existing aquatic resources and associated wildlife and riparian habitat.
Labile	Constantly undergoing or likely to undergo chemical change; unstable.
Leaching	The removal of nutrients, chemicals or contaminants from the soil by water movement through the soil.
Limnology	The area of science dealing with the study of freshwater aquatic ecology.
Mass flux	The input or gain and output or loss of materials (such as nutrients) to an area such as a body of water.
Mass wasting	A general term for a variety of processes by which large masses of earth material are moved by gravity either slowly or quickly from one place to another.
Mesotrophic	Descriptive of lakes in transition from oligotrophic status toward eutrophic. They are still generally pristine, but fish species are mixed, nutrient levels are higher and water is not quite as crystal clear.
Mitigation	An action designed to lessen or reduce adverse impacts; frequently used in the context of environmental assessment.
Nitrogen	A chemical element used in fertilizer as a nutrient (also a component of animal wastes). It can promote algal blooms that cause eutrophication if it runs off or leaches out of the surface soil.
Nonpoint source	A diffuse source of water pollution that does not discharge through a pipe. This may be agricultural or urban runoff, or runoff from construction activities.
Nutrients	Elements or compounds essential to life, including carbon, oxygen, nitrogen, phosphorus, and many others.
Nutrient budget	The quantity of a given element or compound available for plant productivity over time. Changes in plant productivity are directly related to changes in the nutrient budget.
Nutrient loading	Increases in the nutrient budget attributed to either increases from human-related or natural events.
Oligothrophic	Descriptive of crystal-clear lakes characterized by cold water fish species, low nutrient content and generally pristine features.
Ortho phosphorus	The form of phosphorus most available to algae for growth.

Particulate organic carbon	Carbon content of particles in the water derived from living organisms (includes algae, waste products, dead or decayed organisms).
Permeability	The capacity of porous rock, sediment, or soil to transmit water.
pH	A measure that indicates the relative acidity or alkalinity of a substance. The pH scale ranges from 0 (most acid) to 14 (most basic), with a pH of 7 being neutral.
Phaeophytin	Formed when Chlorophyll *a* degrades. Data are used to correct for degradation of Chlorophyll *a* that might occur between sample collection and analysis.
Phosphorus	One of the primary nutrients required for the growth of aquatic plants and algae. Phosphorus is often the limiting nutrient for the growth of these plants. (See nitrogen.)
Point source	Discernible sources of pollution, such as pipes, ditches, channels, wells, containers, concentrated animal feeding operations, or other vessels.
Primary productivity	The ability of a body of water to grow algae.
Recharge	The processes involved in the addition of water to the zone of saturation; also the amount of water added.
Revegetation	The planting of ground cover on highly erodible and marginal lands as a means of preventing further erosion.
Riparian	Located or living along or near a stream, river or body of water.
River hydrograph	The pattern of a river or lake expressed as in-flow and out-flow ratios (such as cubic feet per second) and containing temperature, chemical and other expected characteristics.
Runoff	Water from rain, snow melt, or irrigation that flows over the ground surface and returns to streams. It can collect pollutants from air or land and carry them to the receiving waters.
Secchi Disk	A 20cm reflective disk used by volunteers and professional researchers to determine water clarity and derive a value used in computing a lake's trophic status.
Sediment	Solid material (silt, sand, or organic matter) that has been moved from its site of origin and has settled to the bottom of a watercourse or water body. Excessive amounts can clog a watercourse. If disturbed, it can contribute to turbidity.
Sedimentation	The deposition of sediment from a state of suspension in water or air.
Solubility	The capacity to be dissolved or liquefied.
Suspended solids	Solids floating in the water column that generally impart a cloudy appearance to water, sewage, or other liquids.
Terrestrial	Living or growing on land rather than in water or air.

Tertiary waste treatment	Selected biological, physical, and chemical separation processes to remove organic and inorganic substances that resist conventional secondary treatment practices.
Total Maximum Daily Load (TMDL)	A U.S. Environmental Protection Agency strategy to determine the maximum level of pollution that can be permitted to enter a body of water if water quality is to be maintained at a given level.
Total suspended solids (TSS)	Solids, found in waste water or in a stream, which can be removed by filtration. The origin of suspended matter may be man-made wastes or natural sources such as silt.
Tributary	A steam that contributes its water to another stream or body of water.
Trophic status	The descriptive phase of a lake: oligotrophic, mesotrophic, eutrophic or somewhere in between. (Flathead Lake currently is described as oligo-mesotrophic).
Turbidity	Haziness or cloudiness in water because of suspended silt or organic matter.
Voluntary Nutrient Reduction Strategy (VNRS)	The voluntary strategy through which the Flathead Basin Commission will work with local groups and individuals to identify and implement the non-regulatory means to achieve the Total Maximum Daily Load (TMDL) for Flathead Lake.
Water column	A cross section of a body of water from a point on the surface, straight down to the bottom.
Water cycle	The continuous circulation of water in systems throughout the planet, involving condensation, precipitation, runoff, evaporation and transpira tion.
Water pollution	Harmful or objectionable material in water in sufficient quantities to result in a measurable degradation of the water quality.
Water quality	A term used to describe the chemical, physical, and biological character istics of water with respect to its suitability for a particular use.
Watershed	The area of land that drains into a particular watercourse or water body.
Wetlands	Any land area that tends to be regularly wet or flooded.
Zooplankton	Plankton that is composed of tiny animals and animal matter.

Commission Budget

The Flathead Basin Commission receives state funding from the Resources Indemnity Trust Water Development Fund. In addition, the Commission actively seeks financial, in-kind and volunteer support from other sources. The information below summarizes sources of funding, contributions received, and how financial resources were allocated for the 1995-1996 Biennium, and is intended for general informational purposes only.

Funding	**Sources**
RIT Water Development Fund	$82,400
Flathead County	1,800
Total Direct Funding Assistance	84,200
Funding Allocations	
Staffing	71,500
Office Operations	
Communications	4,150
Supplies and Materials	1,950
Travel	950
Office Rent	1,800
Biennial Report Preparation and Publishing	4,150
Other Services	1,500
Total Expenditures	84,200
Special Projects and Grants	
Monitoring Master Plan	
MDEQ	$60,000
Flathead County	10,000
Montana Power Company	10,000
Flathead City-County Health Dept.	6,800
Flathead National Forest	100,000
Friends of the Wild Swan	3,534

In-kind contributions include technical assistance from the University of Montana Biological Station, Confederated Salish & Kootenai Tribes, MDNRC Forest Mangement Bureau, Flathead National Forest and the National Park Service.

Flathead Lake Total Maximum Daily Load (TMDL) Study

U.S. EPA Grant $150,000
(Funding used to carry out TMDL Study)

Voluntary Nutrient Reduction Strategy (VNRS) Education Project

MDNRC Grant $100,000
(Active phase of project to be initiated in 1997. Only one percent expenditure to date)

In-kind and Volunteer Assistance

Volunteer Monitor Program participants	900 hours
Green Thumb Program	1,000 hours

Scientific Report Section

This Water Quality Monitoring Report is derived from various research documents and from discussions with the researchers. The basic reports from which information was taken include:

"Influences of Nitrogen and Phosphorus Loading on Water Quality in Flathead Lake, Montana. Open File Report 134-95" (1995, by Jack A. Stanford, Bonnie K. Ellis and G.C. Poole, Flathead Lake Biological Station, University of Montana, 311 Bio Station Lane, Polson, Montana 59860)

"Analysis of 1994-1996 Headwaters Monitoring Data. Open File Report 140-97" (1997, by F. Richard Hauer, Flathead Lake Biological Station, University of Montana, and Elizabeth Hill, Flathead National Forest, U.S. Forest Service, available from UM Biological Station, 311 Bio Station Lane, Polson, Montana 59860)

"Biennial Report: Monitoring Fisheries Habitat and Fish Populations in the Flathead Basin" (1996, by Tom Weaver, MFWP, 490 North Meridian, Kalispell, Montana 59901)

"Biennial Report on Surface Water Quality of the Stillwater State Forest" (1996, by Paul Callahan, MDNRC Forest Management Bureau, 2705 Spurgin Road, Missoula, Montana 59801)

"1996 Forestry BMP Audits Final Report" (MDNRC Forestry Division, 2705 Spurgin Road, Missoula, Montana 59801-3199)

"Volunteer Monitor Program 1992-1995 Comprehensive Report")1996, Flathead Basin Commission, 723 Fifth Avenue East, Kalispell, Montana 59901)

Notes

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Phone: 406.752.0081
Fax: 406.752.0095
Email: fbc@digisys.net

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